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A STUDY OF SOME FACTORS AFFECTING CARCASS QUALITY

By

Thomas William Hall

Department of Animal Husbandry

University of Alberta,

April, 1940.

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By Thomas William Hall.

A THESIS

submitted to the Department of Animal Husbandry of the University of Alberta in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE.

University of Alberta.

April, 1940.

PREFACE.

I wish to thank Professor J. P. Sackville, Head of the Department of Animal Husbandry, University of Alberta, for affording me the facilities of his Department. The whole-hearted cooperation of Swift Canadian Packing Plant Officials, and Officials of the Dominion Department of Agriculture in carrying out certain phases of the work entailed in grading and processing the carcasses is gratefully acknowledged. Many thanks are due also to Mr. G. Gines who devoted much of his time to the care of the experimental animals. I am particularly indebted to Dr. R. D. Sinclair, Professor of Animal Husbandry in Charge of Swine, University of Alberta, who initiated each of the experiments herein reported, and who, through helpful criticisms and suggestions rendered much valuable and appreciated assistance in carrying out the projects and in the preparation of this manuscript.

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A STUDY OF SOME FACTORS AFFECTING CARCASS QUALITY IN THE BACON HOG

INTRODUCTION.

The production of bacon hogs and "Wiltshire Sides" is today an industry of paramount importance in Canada. Comparatively speaking, the industry has been developed slowly but it would appear to be sound in conception and to have a definite objective.

In the development of Canada's bacon industry, the British market has served as a standard. The various practices and processes involved in the production of the finished product have been outlined and conducted with an eye to this market. The importance of the British market to the Canadian swine industry is indicated by the fact that in 1935 the product of over one million hogs out of a total government inspected kill of two million eight hundred thousand hogs found its way to this market.

As Great Britain is the chief bacon importing country in the world, and all countries with a surplus of pig products look to her for a market, naturally there is keen competition.

Great Britain is also the world's greatest outlet for beef and mutton, thus competition in meats af all varieties is extremely keen in this market.

In normal times, the world surplus of meat and meat products is far in excess of the needs of the British Isles, particularly when home production is aafeguarded by protection policies.

This places Great Britain in a very favorable position when dealing with livestock producing countries having a surplus.

To compete successfully in the British market for meat products, the product must meet, both in quality and type, with the preferences of the British consumer, no matter what the ideas of the exporting country may be as to what constitutes a high quality in that product.

Regardless of the fact that Canada holds an enviable position with regard to volume of export of bacon products to Great Britain, some discrimination is made against the Canadian product. Much of the Canadian bacon sold overseas commands a low price in comparison with the price received for bacon from other countries which indicates that the quality of the product is not highly regarded by the British consumers.

Befor discussing in what way Canadian export bacon is lacking in quality, it may be stated that the majority (70 to 75 percent of the total weight) of Canadian bacon is exported as "Wiltshire Sides". The term "Wiltshire" as applied to Canadian bacon has a somewhat interesting history. It is recorded that the typical bacon product of Great Britain was at one time made only from hogs that were produced in the Wilts District or Shire of England. The Wiltshire method of cutting a carcass spread far beyond the Shire and when William Davies, the founder of the Canadian export bacon trade, investigated the possibilities he chose the Wiltshire style of bacon as the best to adapt to Canadian purposes.

The "Wiltshire" side comprises one entire half of the carcass of a bacon hog which has been trimmed according to a

standard procedure. The head, feet, shoulder blades, leaf lard, tenderloin, neck bone, back bone and minor trimmings are removed.

These "Wiltshire" sides must possess certain characteristics before they meet with the full approval of the British Consumer. Some of these may be stated as follows:

1. Uniform weights averaging around 55 to 65 pounds.
2. Good length from the first rib to the hip bone.
3. Shoulder light.
4. Ham trim, but well developed and carried with meat down to the hock.
5. Evidences of a high percentage of lean as indicated by lack of any excess fat; an even covering of fat from 1¼ to 1½ inches along the back is most desirable.
6. Belly thick, as indicated by fullness and firmness in the region of the flank.

Many of the "Wiltshires" exported from Canada do not measure up to these requirements and are therefore said to lack quality. The British meat retailer finds that Canadian Wiltshire sides,

1. Are too heavy in the shoulders.
2. Do not show sufficient length of middle piece.
3. Lack in development of ham.
4. Contain too high a percentage of fat to lean throughout the entire side.

In considering the causes of these undesirable characteristics mentioned above, it is of course obvious that the type

of bacon hog raised has an all important bearing on the type and quality of carcass that will be produced. If the highest quality "Wiltshire sides" are going to be produced, and they must be if Canada is going to successfully compete in the British bacon market, then only the best type of bacon hog must be raised. Such a hog will show good length of side, an even arch of back from neck to tail which is indicative of uniformity of fleshing, and an evenness of width throughout the body which suggests good development of back, loin and ham in relation to shoulder. There will be good depth of body, but freedom from excess fat at the underline, jowl, and ham facings which insures a leaner carcass and consequent freedom from waste.

Experience has shown that some strains of bacon-type pigs are more consistent producers of high class carcasses than are other strains, thus showing that "breeding" is a most important factor and one that must be given serious attention.

Notwithstanding the fact that, as has been pointed out, breeding plays a major role in determining the type of bacon hog that is produced and the quality of the subsequent bacon product, it has been quite definitely established that feeding and management practices are also of paramount importance. In other words, a bacon type pig which from the standpoint of breeding has potentialities of producing a carcass of the highest quality may by improper feeding and management methods on the part of the producer be rendered incapable of producing such a carcass.

Not only must the Canadian bacon producer be concerned over those characteristics with which the English consumers

find fault but with others as well. For example, such characteristics as over-finish, under-finish and "soft fat" prevent much Canadian bacon from being placed on the British market. Bacon of this type is definitely lacking in quality and it is felt that feeding and management practices may have much to do with the production of such bacon.

It would appear to be quite obvious that before sound advice can be given regarding feeding and management practices as related to the production of bacon-type hogs, these fields must be fully explored.

It was with a view to gaining further information in these fields and to discovering in what ways various feeding and management practices do affect carcass quality that a number of experiments were carried on at the University of Alberta. It is the purpose of this thesis to discuss these experiments and to present the results obtained. It might be pointed out here that the experiments which were outlined deal with somewhat different problems, but nevertheless the main purpose behind each of them was to explore the field of swine feeding and management practices as related to the production of a high quality bacon product. The problems to be dealt with may be briefly stated as follows:

1. The effect of varying the protein level in the ration, on the growth of the bacon hog and on the general quality of the carcass produced by such a hog.

2. A comparison of the merits of certain protein supplements in the production of high quality bacon.

3. A study of the influence of exercise and "outside

feeding" as compared with "inside feeding" on the general carcass quality of the bacon hog.

4. A comparison of different planes of nutrition and their effect on the quality of carcass produced.

5. The influence of external temperature on the firmness of fat in the bacon hog carcass.

6. A determination of the relative amount of "finish" carried by bacon hogs when slaughtered at different weights.

7. The sex of the animal in relation to the quality of the carcass.

Before entering into a discussion of the experiments it would seem logical to review the literature relevant to the problem, to refer to similar work that has been carried on along this line and to present the findings of other closely related studies.

REVIEW OF LITERATURE.

Protein and Nutrition.

The statement has been made that, "without protein there can be no life."

Proteins play a predominating role in the life processes of every animal cell. They enter into the construction of nearly all animal body tissues, form the chief constituent of many body fluids and are concerned in many of the physiological processes which are continually going on in the animal body.

Such authorities on nutrition as McCollum (1), Chittenden

(2), Maynard (3) and Armsby (4) point out that proteins are necessary for the proper development and functioning of the animal body. Such being the case, it would appear that proteins are necessary in the diets of all animals if proper growth, development, and normal functions of the body are to take place.

In dealing with the problem of protein requirements of the animal body, early workers in this field concerned themselves chiefly with the amount of protein which was necessary for normal metabolism. In other words, only the quantitative aspect of the question was given consideration. More recent investigations, however, have been concerned with the qualitative phase of the problem.

Magendie (5) produced the first evidence that all proteins were not of equal value. He showed that gelatin would not take the place of meat protein in the diet. In 1914, Osborne and Mendel (6) showed that certain proteins which resulted in nutrition failure when used alone were rendered satisfactory by the addition of missing -amino acids. For example, rats on a diet which was otherwise adequate but contained zein as the sole protein, failed to grow and lost weight. Growth was resumed when lysine and tryptophane, two amino acids not present in zein, were added. The addition of tryptophane alone enabled the animal to maintain its weight but no growth occurred until lysine also was added. Fundamental findings such as those mentioned above led to the realization that the value of a given protein in nutrition is primarily determined by its amino-acid make-up. It is now known that there are certain

amino acids which the body cannot synthesize adequately and which are known as "essential amino acids". Those amino acids which can be synthesized by the animal body are known as non-essential. The discovery that many of the amino acids composing body protein must be supplied as food by such, explains why different foods and rations of the same protein content have different protein value in nutrition. Any food which is an efficient source for the essential amino acids is said to have a high biological value.

Studies by Mitchell and Kick (7) indicate that certain proteins mutually supplement each other so that the resulting amino acid mixture has a biological value superior to that of either protein when fed alone.

Maynard (3) points out that since the body contains many different proteins having somewhat different amino acid relations, the usefulness of the food proteins depends in part on the purpose for which it is fed. The amino acid requirements for maintenance may thus be somewhat different from those of growth.

It is obvious that both quality and quantity must be taken into consideration in any complete discussion on protein as related to animal nutrition.

Protein as Related to Growth and Carcass Quality.

Growth is a complex process and not simple to define. Schloss (8) defines growth as a "correlated increase in mass of the body in definite intervals of time, in a way characteristic of the species." Maynard (3) states that true growth involves an increase in the structural tissues such as muscle

and bone, and also in the organs, and suggests that this should be distinguished from the increase that results from fat deposition in the reserve tissues. Growth is characterized primarily by an increase in protein, mineral matter and water.

Chaney and Ahlborn (9) suggests that the requirement for protein is high at those times in life when growth occurs. Shaw (10) is of the opinion that shortage of protein affects materially the early growth of the animal but has very little effect during the later stages of growth. Curtiss and Craig (11) found that by feeding a ration made up chiefly of carbonaceous feeds to swine they obtained a carcass containing an excessive amount of fat; whereas by feeding a ration with a narrower nutritive ratio they obtained a carcass showing much less fat and a greater amount of lean meat. Joseph (12) suggests that when the supply of protein is deficient in either quality or quantity the amount of body protein is directly affected.

The above findings and assertions would seem to indicate that the amount of protein in the ration has direct bearing on the amount of protein in the animal body to which it is fed.

Swanson (13), however, states that a large amount of protein in the ration fed will not necessarily produce a pig with a high protein content. He suggests that the effect of a larger amount of protein in the ration would be to produce more rapid growth, but not the final protein content. Murray (14) reporting on experiments conducted at the University of Alberta states that the rate of growth of hogs receiving rations containing varying levels of protein showed a gradual

increase up to a point where protein was fed at the average level of 10 percent, but feeding protein in excess of this proportion did not result in any further increase in the rate of growth. Murray (14) also suggests that feeding protein at varying levels to the growing bacon hog does not vary the percentage of lean meat which is produced in the carcass nor does it affect the length of carcass.

Work conducted at Cambridge by Woodman et al (15) led to results similar to those obtained by Murray (14). In reporting this work Woodman and his coworkers point out that increasing the protein level above certain limits did not increase the growth rate of pigs, and that an increase in the percentage of protein rich food to an abnormally high level caused a small though significant depression in the rate of live-weight increase, and a slight increase in the amount of meal required per one pound of live-weight increase. These workers also point out that extremely wide variations in feeding treatment involving a far-reaching replacement of cereal by protein-rich feed, were without significant effect on the thickness of back fat and belly streak. Neither did the feeding of the high-protein ration lead to the production of leaner carcasses as judged on the basis of back fat and on the percentage of fat and lean in three typical rashers from the belly, back and gammon. The character of the feeding was also without significant influence on:

(a) the size of the "eye" muscle and the extent of fat infiltration into the area within the line of connective tissue.

(b) the length of the pigs as measured from the front rib to the pubis symphysis.

(c) the carcass percentages.

(d) the weight of the flares.

It would appear then that the protein content of the ration may have a direct bearing upon the growth of an animal. If the protein is limited too greatly it results in restricted growth, but on the other hand if the amount of protein is increased beyond a certain point, the excess does not result in an increased rate of growth. Furthermore the work carried on by certain investigators (10) and (11) would seem to indicate that the amount of protein in the ration may influence directly the amount of protein in the animal body and subsequently the amount of protein in the carcass. However, other workers (14) and (15) are not altogether in agreement with this.

If under conditions where an excessive amount of protein is included in the ration, the excess protein does not result in an increase in the amount of protein in the animal body, it may well be that the excess protein supplied above that required for growth and maintenance is broken down within the body and used either as a source of energy for immediate use or to build up reserve energy in the form of fat.

That protein may be deaminized and the non-nitrogenous residue used as a source of energy or converted into fat is pointed out by various authorities (3), (16), (17).

Woodman and his coworkers (15) are of the opinion that in cases where protein is fed in excess of the nitrogen re-

quirements for maintenance and for synthesis of body protein, deamination of amino acids does take place.

The Effect of Exercise on Carcass Quality.

There seems to be some question as to whether exercise is necessary to develop muscle tissue in the animal body. It is to be expected that a leaner carcass may be obtained from an animal that does receive exercise than from an animal that does not. Hammond (18) suggests that this may not necessarily be due to an increase in the actual amount of muscle tissue, but rather to a reduction in the amount of fat and hence an increase in the proportion of muscle to fat. In support of the idea that exercise may not result in any increase in the actual amount of muscle tissue, he points out that long distance runners do not develop excessively large leg muscles.

Kulbs and Berberich (19) experimenting with both dogs and pigs to determine the effects of exercise, found that under conditions of increased exercise there was an increase in the size of the muscles.

Leighton and Douglas (20) suggest that exercise increases the amount of connective tissue holding the muscle fibres together.

Murray (14) found that the diameters of the muscle fibres in the "infraspiratus" muscle were not increased as a result of increased exercise taken by the animal.

Hammond (21) quoting other investigators (22) and (23), states that exercise does increase the size of the muscle fibre, while Schaffer (24) claims that there is an increase

in the number of fibres rather than an increase in the diameter of those already formed.

There certainly is not full agreement by all investigators as to whether exercise does actually increase the amount of lean in the animal body, nor does it appear to be at all definitely established as to how such an increase, if it does take place, is brought about.

Age of Pigs and Methods of Feeding as Related to Carcass Quality.

It seems quite possible that different methods of feeding pigs may have a significant effect on the quality of the carcass produced. In other words, subjecting pigs at different ages and consequent different stages of development to varying planes of nutrition may have some effect on the quality of the carcasses from such pigs. Muscle development and fattening probably go on simultaneously. Armsby (4) regards muscle development and fattening as two distinct processes, but considers them both involved in the process of growth where growth is taken to mean entire body development. He makes the suggestion that fattening should be so regulated that it will be completed when the rate of gain of lean meat ceases to be profitable. Hammond (18) emphasizes the importance of considering the proportion of lean to fat at different stages of development, and suggests that due to body development it may be advisable to grow pigs rapidly at first while muscle is developing and finish them more slowly as fattening takes place. Apparently Hammond is of the opinion that there are stages in the development of the pig at which muscle develop-

ment takes place more rapidly than at others. Rothwell (25) suggests that allowance should be made for maximum muscle and bone development before too much fattening takes place. The statement has been made (26) that "any system of feeding a bacon pig that tends toward the too early laying on of fat and prevents the maximum growth of bone and muscle during the first four months tends towards the development of a thicker, shorter carcass and away from the type that will make it a "lean" or 'leanest' side."

Mansfield, Trehane and Peacock (27) after conducting an experiment to compare restricted with ad lib feeding, arrived at the following conclusions:

1. Restricted as opposed to unrestricted feeding definitely improves the quality of the carcass.

2. The optimum level of feeding though not definitely determined, seems to be in the neighborhood of three-quarters of the quantity that the pig will consume if given as much as it will eat.

3. If restriction is carried too far the rate of live weight gain is reduced to such a level that the quality of the fat is adversely affected, and there is a tendency for "soft" fat to be produced.

4. Restricted feeding tends to improve the efficiency of the pigs.

McMeekan (28) reports work done at Cambridge to determine the changes in composition and relative proportions of the pig with age. He suggests that growth in those pigs studied proceeded by a series of "waves" starting from the head, the

extremities of the limbs and from the tail, and meeting in the loin. In addition, the three tissues, bone, muscle and fat, develop in that order.

Further work at Cambridge reported by McMeekan (28) to study the effect of planes of nutrition on carcass composition, show that the plane of nutrition affects most the latest developing parts of the body. Thus bone which develops early in life, continued to grow in the "low plane" animals, but very little fat was deposited. Similarly, the late developing loin is the joint which is most adversely affected by a low plane of nutrition. The report suggests that a low plane of nutrition in early life stunted the development of bone and muscle and the subsequent high plane of nutrition favored the development of an excessive amount of fat. On the other hand a high plane of nutrition up to sixteen weeks favored the growth of the early developing bone and muscle and the subsequent low plane of nutrition prevented the deposition of excessive amounts of fat. McMeekan concludes by saying, "It has thus been shown that the loin which is the most valuable part of the pig's carcass, is the joint which is most adversely affected by poor nutritional conditions and restricted growth in early life followed by rapid fattening to bacon weight, produces a carcass in which the lean meat is underdeveloped and the covering of fat excessive.

Hammond (18) suggests that instead of the old system of a store period after weaning followed by a period of rapid fattening towards the end of the feeding period, it would be more suitable for the production of first-class lean bacon,

to grow the pigs quickly in the early stages when the muscles are developing, and finish them more slowly later when the fat is developing.

Soft Bacon.

Hogs which dress out "soft carcasses" represent a source of loss to the swine industry. Sides from such carcasses are debarred by the Official Grades from shipment to the export market as "Wiltshires" even if they are of suitable type and finish.

A soft carcass may be described as a carcass which after thorough cooling fails to firm up. While in some cases the lean meat may be very soft and lacking in body, it would appear that the problem of soft bacon is chiefly associated with soft fat.

Sinclair (29) states that "there would appear to be general agreement on the point that the objectionable feature of the soft carcass lies in the soft or oily nature of its fat, which in turn is due to the percentage of unsaturated fatty acids which it contains".

It has long been recognized that the feed which swine receive has a direct bearing on the texture of the fat in the carcass. Morrison (30) states, "it has been known that certain feeds, especially soybeans, peanuts, rice bran, rice polish and chufar, tend to produce soft pork when fed to pigs in considerable amounts."

Extensive investigations (31), (32), and (33) in the United States have shown that body fat which swine make from carbo-

hydrates or protein in their feed has a melting point sufficiently high to be hard and firm at ordinary temperatures. However, it has been shown that fat in the feed may be converted into body fat with but little change. Therefore when swine receive feeds which are high in fat, much of the fat deposited in their bodies comes from this source. Since the fat in such feeds is liquid at ordinary temperatures, soft pork may result when they are fed.

Fortunately Canadian hog producers are not forced to use feeds which are excessively high in fat or oil, for pig feeding purposes, and therefore no serious trouble is encountered along this line. However, it has been suggested that the common Canadian cereals such as oats, wheat and barley, may give rise to soft pork when fed to pigs if such grains are not properly supplemented. It may be that feeding cereal grain alone without proper supplement results in a state of unthriftiness in the pig and this in turn results in soft fat in the carcass.

Some consideration has been given to the possibility that large amounts of frozen wheat in the ration may result in soft carcasses. Sinclair (29) investigated this angle of the problem and reports as follows: "When frost damaged wheat was fed in a winter experiment, a high percentage of soft carcasses was produced, but in as much as similar results were secured with wheat of good quality and with barley, it seems apparent that the frost damage per se was not responsible for the condition."

It would appear that the thrift of the pig or state of

physiological activity may have a direct bearing on the firmness of the fat in the carcass after slaughter.

Day (34) and (35) who was perhaps one of the first to investigate the soft pork problem as related to the swine industry in Canada, suggests that unthrifty hogs are more likely to produce soft bacon than thrifty well fed hogs. Shutt (36) is also of the opinion that lack of thrift may be one of the causes of soft pork.

Friis (37) suggests that there may be some connection between the temperature prevailing during the period of development in the pig and the firmness of fat in the carcass.

Henriques and Hanson (38), (German investigators) in 1901 expressed the opinion that the temperature at which fat was stored might have an effect on the chemical composition of fat in a pig's body. In an experiment designed to deal with this point, these investigators used litter mate pigs fed the same feed under different temperature conditions and received a deposition of fat on their backs with melting points and iodine numbers correlated with the external temperatures at the time of deposition.

Ewing (39), in making studies on the Fort Worth, Texas, market has found that the percentage run of "soft hogs" ranged from as low as 4 percent for one week in the latter part of summer, to as high as 40 percent in one week in March, 1918, following a severe winter.

Sinclair (29) postulates that the temperature under the skin of the pig may be lowered during severe spells of cold weather under conditions where shelters are inadequate, with

a tendency to the deposition of fat of a lower melting point and a higher iodine number. In this connection he points out that 150 fat samples from pigs raised during summer months showed an average iodine number of 58.2, while 72 samples from pigs raised during the winter months showed an average figure of 63.2.

Effect of Sex on Carcass Quality.

Results of experiments conducted by Woodman and others (15) indicate that the influence of sex on carcass quality and conformation, were of a more positive character than those relating to the effect of feeding. According to these workers, statistical analysis of post slaughter results showed that the gilts produced somewhat leaner carcasses as a whole than the hogs.

These workers suggest that the general averages for the percentages of fat in the complete rasher show that the gilts on an average produced a significantly leaner rasher than hogs. The gilts had on the average a significantly larger "eye" muscle than the hogs and consistent with this was the finding that the eye muscle of the gilts averaged a significantly higher percentage of the area within the line of connective tissue than did that of the hogs. In other words, there was significantly less fat infiltration in the case of the gilts.

On the other hand, Jari (40) working in Sweden, found that gilt carcasses were thicker and had a higher content of fat than those of the barrows.

Hammond and Murray (41) suggest that carcasses produced

by sows are thicker in the belly and show less back fat than those yielded by the castrated male pig. These workers state that "the reasons why the sow gives a carcass of better quality are probably twofold. In the first place, castration tends to the deposition of fat in the body, and in the second place, the presence of ovaries in the sow tends to thicken the mammary gland region."

Carcass Quality Explained.

The term "carcass quality" has been used frequently in both the foregoing introduction and review of literature, and as it will be referred to quite frequently throughout the body of this thesis, it may be well to offer some explanation as to what is meant by this term.

From the point of view of common usage, the term "carcass quality" as applied to the bacon hog carcass, refers to the general dimensions and proportions of the carcass, together with the relative amounts of fat and lean meat which it contains. The term also embraces the variations in the composition of the fat.

The Canadian standard of carcass quality is determined by the demands of the British market. Carcasses of the highest quality are long of side, carry a light weight shoulder and a fully developed ham. The external covering of fat should be comparatively light and of uniform thickness throughout, so that a cross-section through the carcass will have a general appearance of leanness rather than of excess fat. The carcass should show no tendency to softness but should be firm.

Having pointed out briefly what is meant by carcass quality as applied to the bacon hog carcass, and having reviewed some of the literature discussing the various factors which influence carcass quality, the experiments conducted at the University of Alberta and upon which this thesis is based, will now be discussed.

EXPERIMENTS CARRIED ON AT THE UNIVERSITY OF ALBERTA.

The experiments reported in this thesis were carried on at the University of Alberta over a period of time extending from the winter of 1936-37 to the winter of 1939-40, and were outlined with a view to gaining information on some factors which may influence carcass quality in bacon hogs. The objects of the experiments may be stated as follows:

1. To study the effect of varying the level of protein in the ration on the growth of bacon hogs, and on the quality of the carcasses produced by such hogs.

2. To compare the relative merits of skim-milk and a mixed protein supplement in the production of high quality bacon.

3. To note the influence of exercise and "outside feeding" as compared with "inside feeding" on the general carcass quality of the bacon hog.

4. To compare different planes of nutrition and to note the effect of such planes of nutrition on the quality of carcass produced.

5. To study the influence of external temperature on the firmness of fat in the bacon hog carcass.

6. To determine the amount of "finish" carried by hogs slaughtered at different weights.

7. To ascertain the influence of the sex of the animal on the quality of carcass produced.

Methods of Experiment.

In general, all experimental animals received the same treatment from the time they reached standard market weights until they were slaughtered. Upon reaching standard market weights, all of the animals were trucked to the Swift Canadian Packing Plant located at North Edmonton. Here they were officially graded by Dominion Government Swine Graders, then slaughtered and dressed according to regular abattoir routine. For a period of from 36 to 48 hours, the carcasses were chilled at a temperature ranging from 28 degrees F. to 34 degrees F., following which they were measured and cut according to Dominion Government Advanced Registry standards. Hot and cold dressed weights were recorded.

In all cases the right side of the carcass was used for making determinations. The following measurements were recorded: (See also Plate I)

(a) Length of side -- the distance from the point of the first rib to the point of the hip bone.

(b) Depth of shoulder fat.

(c) Depth of back fat.

(d) Depth of loin fat.

(e) Maximum belly thickness.

(f) Minimum belly thickness.

(g) Width of side at heart girth.

(h) Width of side at flank.

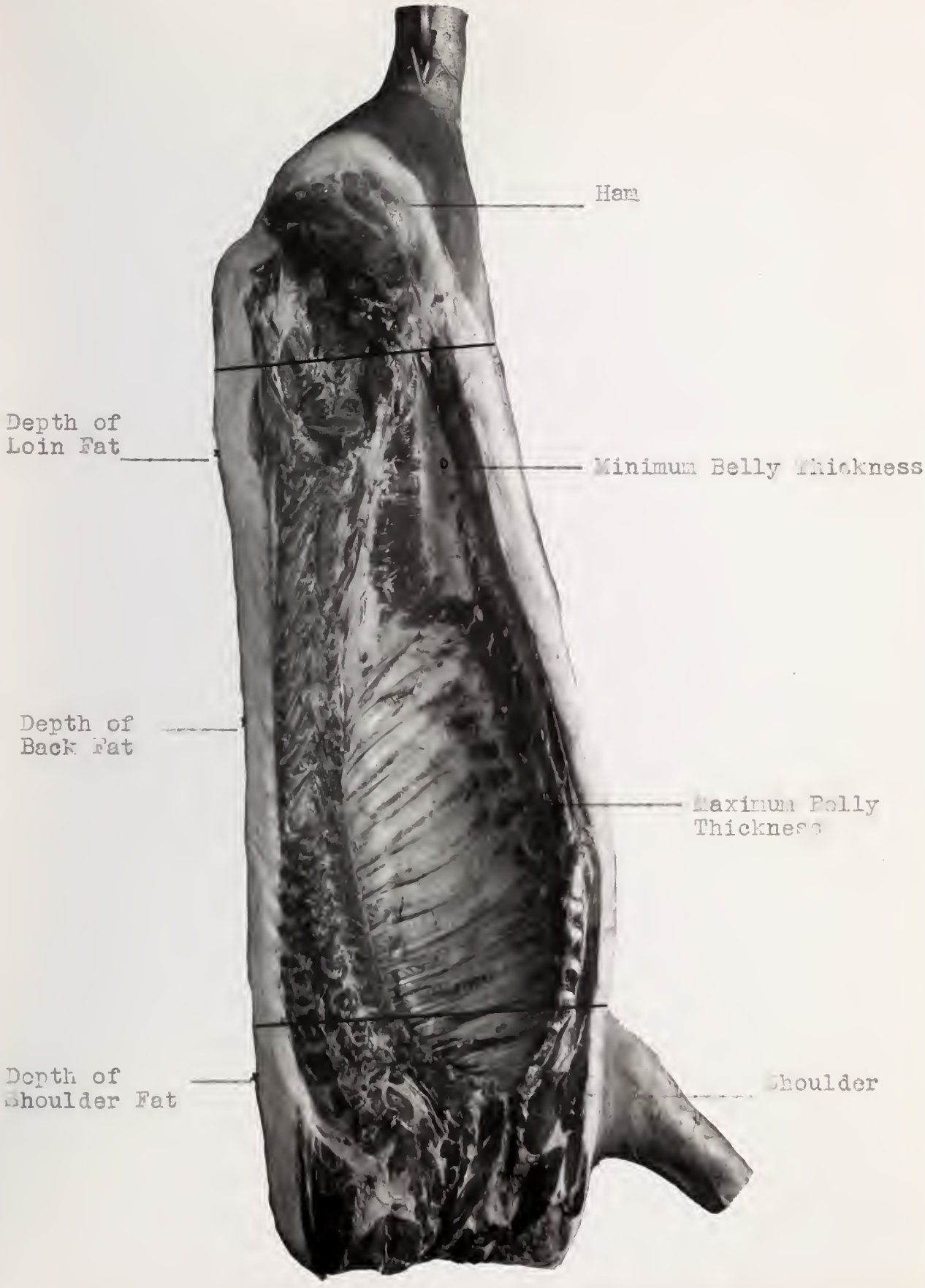

Plate I: Showing some points of measurement on a Wiltshire Side.

Following the procedure of taking the above measurements, the right half of each carcass was cut into these sections:

(a) Shoulder:

That portion of the side anterior to a cut made parallel to the width of the side, across the third rib.

(b) Ham:

That portion of the side posterior to a cut made parallel to the width of the side, two inches to the anterior of the hip bone.

(c) Middle:

That part of the side remaining after shoulder and ham had been removed.

A sample for making further and more detailed studies on the quality of the carcass was taken from that portion of the side designated as middle. Such samples were approximately two inches in thickness, and were taken immediately posterior to the last rib, so that they represented a part of the side cut parallel to the transverse subcostal line of the carcass and including on the ventral line the last thoracic vertebra. Therefore each sample showed the "eye of lean" or longissimus dorsi muscle, the external oblique, internal oblique, transverse, abdominus and a small portion of the rectus abdominus muscles. It also illustrated the covering of fat over the back and belly, and the amount of inter-muscular fat.

After being taken, the samples were immediately frozen and left in this condition until they could be taken to the laboratory at the University of Alberta. Freezing the samples held them in their original form and prevented deterioration.

At such times as the samples were brought from the freezing room at Swift's Packing Plant to the laboratory at the University, tracings were made of each individual sample on a pane of "frosted glass". By placing the frosted glass panes over a light, it was possible to transcribe each tracing on a sheet of paper. This latter served as a permanent record and it was from these tracings that all area measurements were made.

A planimeter was used to determine the area of the face of the sample, and the area of the various muscles. From the figures obtained it was possible to determine the percentage of lean and fat in the sample and also the percentage of the whole represented by the longissimus dorsi muscle.

In some cases, a small cube of fat was removed from the carcass and sent to the Provincial Analyst for determination of the Iodine Number. These samples were removed from the carcass above the junction of the sacrum and lumbar vertebrae and included a cross section of the fat layer. The backfat sample was used since it was found in American investigations that fat from this region was more representative of the fat in the carcass than that removed from other locations.

Weights and Feed Consumption.

All experimental animals were weighed on three consecutive days at the beginning of the experiment and the average of these three weights was taken as the initial weight in each case. Individual weights were taken every fourteen days throughout the duration of each experiment. All feed consumed during the experiments was weighed and the amounts recorded.

EXPERIMENT NO. I. (SUMMER 1937).

The Effect of Varying the Amount of Protein in the Ration fed to Pigs, on the Growth of the Animals, and on the Quality of the Carcasses Yielded by the Animals:

Objects of the Experiment:

The objects of this experiment may be stated as follows:

1. To study the effects of varying the level of the protein in the ration on the growth of the bacon hog, and on the quality of the carcass produced by such a hog.

2. To note the influence of discontinuing the practice of feeding a protein supplement to bacon hogs once they weigh approximately 110 pounds, on the growth and on general carcass quality.

Animals Used:

This experiment included four groups, each group containing five purebred Yorkshire pigs. All groups were selected on the "litter mate " basis and were made as uniform as possible with respect to initial weight, sex, type and general condition.

Method of Housing:

All of the animals were confined to the main piggery on the University Farm in pens 8 feet by 10 feet in size. The pens have concrete floors but contain a wooden sleeping platform. Straw was used for bedding and was changed at least every other day. The pigs were never allowed outside of the piggery.

Arrangement of Groups:

The groups were arranged as follows:

Lot I: Standard Grain Ration, Supplement 15% and 6%, Mineral.

Lot II: Standard Grain Ration, Supplement 12% and 6%, Mineral.

Lot III: Standard Grain Ration, Supplement 12% and 0, Mineral.

Lot IV: Standard Grain Ration, Supplement 8% and 4%, Mineral.

The Standard Grain Ration referred to above was made up as follows:-

	Oats (3CW)	Barley (3CW)	Wheat (5N)
Weaning to 110 lbs.:	30 parts	50 parts	20 parts
110 lbs. to Market Weight:	10 parts	60 parts	30 parts

It will be noted that the proportions of the various grains in the mixture were changed when the animals reached a weight of approximately 110 pounds.

Protein Supplement:

The protein supplement consisted of the following ingredients:-

Tankage	50 pounds
Linseed oil meal	25 "
Fish meal	15 "

This supplement was fed in different proportions to the various groups of pigs, the amounts being changed when the animals reached an average weight of 110 pounds, according to the following plan:-

		Supplement fed: to 110 lbs.	110 lbs. to Market Weight:
Lot I	Grain	15%	6%
Lot II	Grain	12%	6%
Lot III	Grain	12%	0
Lot IV	Grain	8%	4%

The results of an analysis of the feeds used are shown below:-

Results of the Analysis of the Feeds included in the Rations:

	Oats	Barley	Wheat	Tankage	Linseed Meal	Fish Meal
Moisture	12.07%	11.82%	12.04%	5.28%	7.77%	7.36%
Fat	4.20%	1.50%	2.15%	13.59%	7.99%	6.80%
Fibre	10.13%	6.77%	2.72%	1.92%	6.62%	----
Crude Protein	9.95%	10.35%	12.31%	46.16%	39.37%	69.37%
Ash	3.22%	2.35%	1.70%	29.03%	5.33%	12.78%
Carbo-hydrates	60.43%	67.21%	69.08%	4.02%	32.92%	3.67%

Mineral:

Ground limestone was fed at the rate of 0.5 pounds in each 100 pounds of the feed mixture.

Salt:

Salt was fed at the same rate as the ground limestone, i.e., 0.5% of the feed mixture.

Method of Feeding:

The pigs in all lots were given a full feed three times daily until they reached an average weight of 110 pounds, and twice daily during the remainder of the feeding period. The meal mixture was mixed with water at the time of feeding and fed in slop form.

Discussion of Ration:

It was shown above that all four groups of pigs on this experiment received a similar grain ration and that the only

distinct variable was the amount of protein supplement added to the feed mixture which the groups received. The main purposes in varying the amount of protein which was added to the grain mixture were to determine if the amount of protein fed had any effect on the growth of the animals and on the quality of the subsequent carcasses produced by the animals, and to determine what effect eliminating the protein supplement after the pig reached approximately 110 pounds in weight would have on these same features. From the results obtained it may be possible to make some suggestions regarding the optimum amount of this particular protein supplement to be added to the ration. It should not be inferred however, that an amount of any particular protein supplement considered to be optimum for that particular supplement, would apply to all protein supplements. As pointed out previously, the quality or biological value of the protein in the protein supplement must receive consideration. However, in this experiment only one protein supplement is being considered and consequently any results obtained will apply only to that particular supplement.

Results of Experiment No. I.

Table I. Average Daily Gains.

	Lot I	Lot II	Lot III	Lot IV
Av. Initial Weight (lbs.)	37.5	36.3	37.3	37.2
Av. No. Days on Expt.	108.0	115.0	131.0	129.0
Av. Final Weight (lbs.)	208.6	211.2	208.0	214.8
Av. Daily Gain (lbs.)	1.59	1.52	1.30	1.38

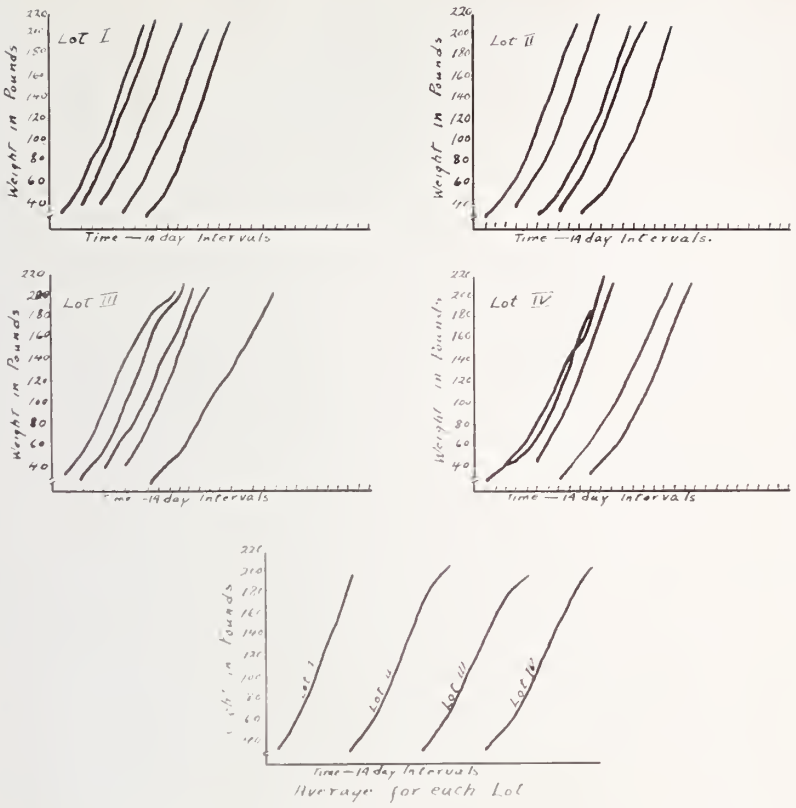

Plate II: Showing the Rate of Growth of the Individuals in the Respective Lots, and the Average Rate of Growth for Each Lot in Experiment I.

It will be seen from these figures that the group which received the greatest amount of protein supplement (Lot I - 15% to 110 lbs. and 6% to finish) throughout the period of the experiment, made the highest daily gains and consequently were on experiment the least number of days. However, Lot II, receiving protein supplement at the rate of 12% and 6%, made almost as good a gain as Lot I, and as will be pointed out later, made somewhat more economical gains. Feeding 12% of protein supplement up until the pigs reached an average weight of 110 pounds and then allowing no further supplement, resulted in much lower gains in weight. The average daily gain was reduced by as much as 0.22 lbs. from that of Lot II. Cutting the protein supplement supply down to 8% and 4% respectively for the two portions of the feeding period, lowered the rate of gain materially, but nevertheless gave better results from the standpoint of gain than did the practice of eliminating the protein supplement entirely after the pigs reached approximately 110 pounds.

A graphical illustration of the growth of the animals is presented in Plate II.

Table II. Feed Required for Growth.

Average Daily Feed Consumed:	Lot I	Lot II	Lot III	Lot IV
Grain (lbs.):	4.88	4.60	4.52	4.70
Protein Supplement (lbs.):	0.49	0.44	0.24	0.27
Feed Required for 100 lbs. of Gain:				
Grain (lbs.):	307.8	301.7	346.4	339.9
Protein Supplement(lbs.):	30.7	28.7	18.3	19.8
Total:	338.5	330.4	364.7	359.7

This brief table shows that Lot II receiving protein supplement at the rates of 12% and 6% had the second lowest daily grain consumption and the lowest total feed requirement for 100 pounds of gain. Lot I which made the highest average daily gains and was on experiment the shortest period of time, had a slightly higher daily feed consumption and required 8.1 lbs. more total feed per 100 pounds live weight increase. Thus the ration containing a smaller percentage of protein supplement, i.e., 12% and 6%, gave almost as good gains as the 15% protein supplement ration, and from the standpoint of practical pig production was more economical. Lots III and IV required somewhat higher feed intakes per 100 pounds live weight than did Lots I and II, and it is again significant to note that Lot III, the group which received no protein from 110 lbs. to market weight, had the highest feed requirements.

The average daily intake of crude protein per 100 pounds live weight, based upon the analysis as shown previously, was as follows:-

	Lot I	Lot II	Lot III	Lot IV
Average Daily Intake of Crude Protein per 100 lbs. live weight:	0.62 lbs.	0.57 lbs.	0.49 lbs.	0.51 lbs.

However, these figures do not represent the average amounts of protein per 100 lbs. of live weight that were used or taken into the animal body proper. There is only a certain percentage of the protein that can be digested.

The average daily intake of Digestible Crude Protein per

100 pounds live weight respectively for the four lots based upon feed consumption and determined according to Morrison's (30) Coefficients of Digestibility, were as follows:-

	Lot I	Lot II	Lot III	Lot IV
Average Daily Intake of Digestible Crude Protein per 100 lbs. live weight:	0.56 lbs.	0.52 lbs.	0.45 lbs.	0.44 lbs.

The figures for the first two lots, i.e. Lot I and Lot II, approximate very closely the figure of 0.55 pounds suggested by Sinclair and McElroy (42). The average daily intakes of Digestible Crude Proteins for Lots III and IV respectively, were 0.07 and 0.08 lbs., less than that of Lot II. It would appear that this lower daily intake of Digestible Crude Protein was a factor contributing to the lower average rate of gain shown by the animals in Lots III and IV. (Table No. I).

It will be noted that the figure of 0.45 shown for Lot III is 0.01 pounds above that of Lot IV. In other words, the average daily intake of Digestible Crude Protein for these two lots was approximately the same, and yet the daily rate of gain for Lot III was somewhat lower. While too definite a conclusion cannot be drawn at this time, it would appear that eliminating the protein supplement after the pigs reached an average of approximately 110 pounds, had a deliterious effect on the growth of the pigs, and was not a sound economical practice.

The Effect of Varying the Protein Content in the Ration Fed to Bacon Hogs on the Quality of the Carcasses Produced:

Reference has been made to what is meant by quality of carcass, and some of the points such as length, fineness of

shoulder and fullness of ham, which characterize quality, have been alluded to. There are also a number of measurements which are used as criteria in determining the quality of a carcass. The depth of loin fat, back fat and shoulder fat, are measurements of the depth or thickness of the fat over these different portions of the carcass. These measurements were taken along the dorsal line at the respective points indicated by the name. The measurements of maximum and minimum "belly" were made at points in the centre portion of the carcass, and they indicate not only the thickness of the side of bacon which will result from the carcass, but also the amount of trimming which has to be done to make the thickness consistent throughout the side. This is a much desired characteristic. (See Plate I).

Table III. Measurements and Percentages of the Cuts of Carcasses.

	Lot I	Lot II	Lot III	Lot IV
Av. Cold Carcass Weight (lbs.)	153.1	151.7	153.6	158.0
Av. Length of Carcass (inches)	30.66	30.90	30.28	30.48
% Shoulder of Carcass	27.85	27.69	28.02	27.71
% Ham of Carcass	23.55	23.54	23.49	23.69
Av. Depth of Shoulder Fat (inches)	1.90	1.90	1.96	1.94
Av. Depth of Back Fat (inches)	1.06	1.04	1.20	1.24
Av. Depth of Loin Fat (inches)	1.50	1.54	1.52	1.60
Av. Min. Belly Thickness (inches)	0.96	0.88	1.04	1.14
Av. Max. Belly Thickness (inches)	1.88	1.84	1.92	2.02

A review of the figures in this table will show that there

indicated by the arrow. The [illegible] is
then "pulled" down into the [illegible]
the groove, and then [illegible] the [illegible]
side of [illegible] will [illegible] from the groove, [illegible]
the [illegible] by [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
connectable. (See Figure 1).

were only small differences in the length or percentage shoulder and ham of the carcasses from the different groups. A brief statistical analysis of the data covering these characteristics is shown in the Appendix - Tables I, II and III. There was a tendency for Lot IV to show a slightly heavier "finish" than the other three groups as indicated by the depth of loin fat, and greater thickness of belly. One explanation for this is the somewhat higher average cold carcass weight for Lot IV.

There are not sufficient consistent differences in the measurements of the carcasses from the respective groups to interpret such differences as being due to the varying levels of protein in the ration.

Detailed Carcass Measurements:

As indicated previously, detailed measurements were made on sections taken from the carcasses, in an endeavor to determine the relative proportions of fat and lean in the carcasses. These measurements are shown in the following table:

Table IVV Detailed Carcass Measurements.

	Lot I	Lot II	Lot III	Lot IV
Av. Total Area of Cross-section (square inches)	27.54	27.08	27.88	29.53
Av. Area of "Eye of lean" (square inches)	3.42	3.40	3.49	3.83
% "Eye of lean" in Cross-section	12.56	12.61	12.51	13.01
% Total lean in Cross-section	30.45	31.00	30.29	29.79

The figures presented show that there were some differences in the average area of the "eye of lean" from the respective

groups. It is significant to note that the greatest average area of "eye of lean" was produced by Lot IV, the group which had the lowest average daily intake of crude protein. This may be partially explained at least by the relatively larger average area of the cross-sections from Lot IV, which in turn was determined by the higher average cold carcass weight of this group. This, however, does not account for the relatively high figure shown for percentage "eye of lean" in cross-section for Lot IV. In view of this, it is evident that the relative proportion of the "eye muscle" to the cross-section was greater in the case of Lot IV than in the other three groups, regardless of the average area of the cross-sections.

There is little difference in the percentage "eye of lean" in the cross-section as shown for Lots I, II and III. Again in these three Lots, the differences in percentage total lean in cross-section are not significant (Appendix - Table IV). However, it may be noted that in the case of Lot IV the percentage total lean in cross-section is somewhat lower. This might be explained on the basis of the slightly greater amount of "finish" carried by the animals in this group. There is an inconsistency in this group, in that the percentage "eye of lean" is greater and the total percentage of lean in the cross-section less than in any of the other groups.

Any conclusion, as far as detailed measurements are concerned in this experiment, must be largely based on the results for Lots I, II and III and these indicate that neither the size of the "eye of lean", the percentage "eye of lean"

in the cross-sections nor the percentage total lean in the cross-sections, are influenced by the average daily intake of digestible crude protein by the animal. With reference to Lot IV, it is apparent that a daily intake of 0.44 lbs. of Digestible Crude Protein per 100 pounds live weight was sufficient to provide for full development of "eye of lean".

EXPERIMENT NO. II. (SUMMER 1938).

A Comparison of the Relative Merits of Skim-Milk and a Mixed Protein Supplement, and a Comparison of Different Methods of Feeding in the Production of High Quality Bacon:

Objects of Experiment No. II:

1. To determine the relative merits of skim-milk and a mixed protein supplement respectively in the production of high quality bacon.

2. To examine the influence of "inside" and "outside" feeding respectively on the growth of bacon hogs, and on the quality of the carcasses produced by such hogs.

From time to time the question arises as to whether or not a superior quality of bacon is produced by bacon hogs which are fed skim-milk, and furthermore, is it possible to produce high quality bacon without using skim-milk in the ration.

The results of earlier experiments conducted by the Department of Animal Husbandry, University of Alberta (43), to study this problem indicated that a higher percentage of

suitable Wiltshire sides was produced by pigs which were fed skim-milk than by those receiving tankage as the protein supplement.

It is a recognized fact that the quality of Danish bacon is high, and that the Danish pig producer uses large amounts of skim-milk and other milk by-products for pig-feeding purposes. These facts would seem to indicate that the use of skim-milk may be an important factor in the production of high quality bacon.

The present experiment was designed to gain further information regarding this problem and also to study the influence of "inside" and "outside" feeding.

Under conditions of outside feeding, the experimental animals have opportunity for unlimited exercise. The question arises as to whether or not this increase in the amount of exercise taken by the animal will result in the production of a carcass showing greater length and a higher proportion of lean meat to fat.

Animals Used:

There were four groups, each group comprising six pure bred Yorkshire pigs, included in this experiment. The lots were balanced as evenly as possible with respect to initial weight, condition, sex, breeding and thrift.

Method of Housing:

Lots I and II were sheltered in 8' by 10' gable type colony houses. Lots III and IV were housed in the main piggery on the University Farm in pens similar to those

described in Experiment No. I. The pigs in these two groups were never allowed outside of the piggery.

Arrangement of Groups:

The arrangement of the groups was as shown below:

Lot I: Standard Grain Ration, Skim-milk, Pasture.

Lot II: Standard Grain Ration, Mixed Supplement, Pasture.

Lot III: Standard Grain Ration, Skim-milk, Inside Piggery.

Lot IV: Standard Grain Ration, Mixed Supplement, Inside Piggery.

The Standard Grain Ration referred to was similar to that outlined in Experiment I and the change in the proportions of the different grains included in the ration was made at a time when the average weight of the pigs was approximately 110 pounds.

Mixed Supplement:

The mixed supplement which was used consisted of the following:-

Tankage	50 pounds
Linseed oil meal	25 "
Fish meal	15 "
Total	90 pounds.

This supplement was fed at the rate of 12% until the average weight of the pigs was 110 pounds and then was reduced to 6%.

Skim-milk:

Skim-milk was fed at the rate of 2 pounds to one pound of grain until the pigs weighed approximately 110 pounds and for the balance of the period at the rate of one pound to one pound of grain.

Ground Limestone and Salt:

were each added at the rate of 0.5 pounds to each 100 pounds of grain in all of the lots.

Pilchard Oil:

was fed to the two lots of pigs in the piggery at the rate of 15 c.c. per pig daily until they reached a weight of approximately 110 pounds.

Pasture:

The two groups of pigs on pasture had the run of an alfalfa pasture from May 31st to August 24th and from August 24th to September 14th a mixed cereal pasture was provided. After September 14th, any pigs remaining in these Lots were fed in outside "dry lots".

Method of Feeding:

All lots were hand fed twice daily, the ground grain being slopped with water before feeding.

Results of Experiment No. II.

Table V. Summary of Average Daily Gains.

	Lot I Pasture Skim-milk	Lot II Pasture Mixed Supp.	Lot III Inside Skim-milk	Lot IV Inside Mixed Supp.
Av. Initial Weight	43.6 lbs.	42.7 lbs.	43.2 lbs.	42.0 lbs.
Av. No. Days on Expt.	120.7 dys.	120.3 dys.	119.3 dys.	120.7 dys.
Av. Final Weight	207.3 lbs.	202.2 lbs.	206.2 lbs.	208.5 lbs.
Av. Daily Gain	1.36 "	1.33 "	1.37 "	1.38 "

These figures serve to show that there were no appreciable differences in the average gains made by the pigs in the dif-

ferent groups. In other words, as far as growth is concerned, the pigs which received skim-milk in their ration did not show any advantage over those which did not receive any milk, nor did those animals on pasture make any greater average gains than those which were fed inside.

Reference has already been made to the possibility that bacon pigs fed on skim-milk may produce a superior quality of bacon and that different systems of feeding such pigs (i.e. inside vs. outside feeding) may influence the quality of bacon produced. The following table shows the measurements and percentages of the cuts of the carcasses produced by the different groups of pigs in Experiment No. II.

Table VI. Measurements and Percentage of the Cuts of Carcasses.

	Lot I	Lot II	Lot III	Lot IV
Av. Length of Carcass (inches)	29.12	29.25	29.45	29.82
% Shoulder of Carcass	28.62	28.58	27.76	27.88
% Ham of Carcass	23.96	24.42	24.26	23.92
Av. Depth of Shoulder Fat (inches)	1.85	1.83	1.85	1.88
Av. Depth of Back Fat (inches)	1.12	1.00	1.07	1.15
Av. Depth of Loin Fat (inches)	1.33	1.30	1.42	1.43
Av. Min. Belly Thickness (inches)	1.03	0.88	0.98	1.00
Av. Max. Belly Thickness (inches)	1.78	1.67	1.78	1.80

A survey of the figures in this table reveals that on the average the carcasses from the "inside fed" pigs showed the greatest length. This certainly contradicts the popular belief that "outside feeding" and exercise are conducive to greater length.

It is significant to note also that the two groups of pigs receiving mixed protein supplement showed a greater

average length than those receiving skim-milk.

There was very little difference in the percentage shoulder of carcass between the milk fed groups and those receiving the mixed protein supplement, but there was an average difference of 1.56 percent between the "inside" and "outside" fed groups, the "outside" groups showing the greater percentage of shoulder.

However, a statistical analysis of these figures (Appendix - Table V) showed that the differences between the groups were not significant.

It may be seen from the data presented that there was no significant difference between the two "inside" fed groups or between the two groups which were fed "outside". The analysis in the appendix indicates that there were no significant differences in percentage shoulder of carcass between Lot I which was fed "outside" and Lot III which was fed "inside", nor between Lot II and Lot IV which were fed "outside" and "inside" respectively. It will be recalled that Lots I and III received skim milk, while Lots II and IV were fed a mixed protein supplement.

Furthermore, it was shown (Appendix - Table V) that there was not a significant difference in percentage shoulder of carcass between the two "inside" fed groups and the two which were fed "outside".

The above results indicate that any increased exercise which the "outside" fed animals indulged in, did not lead to an increase in the size of that portion of the carcass

designated as shoulder.

These results bear out those obtained by Murray (14), who found that neither "rooting" nor any other form of exercise undertaken by the growing bacon hog, would result in an increase in the size of the shoulder.

While there were some differences in percentage ham of carcass between the respective groups, a statistical analysis of the figures (Appendix - Table VI) showed that these differences were not significant.

It is indicated by the "depth of fat" and "thickness of belly" measurements, that slightly more "finish" was carried by the "inside" fed groups. There were some differences in these measurements between the Lots which received skim-milk and those which received a mixed protein supplement. However, such differences were not great nor were they at all consistent, so that definite conclusions could not be drawn regarding any influence which the respective rations may have had on the above-mentioned measurements.

Detailed Carcass Measurements:

Detailed measurements were made on sections which were taken from the carcasses of the pigs in the respective groups, and the results are shown below:

Table VII. Detailed Carcass Measurements.

	Lot I	Lot II	Lot III	Lot IV
Av. Total Area of cross-section (sq. in.)	27.30	24.68	26.73	26.47
Av. Area of "eye of lean" (sq. in.)	4.26	4.25	4.32	3.91
% "eye of lean" in cross-section	15.57	17.22	16.33	14.82
% Total lean in cross-				

The area of "eye of lean" in Lot IV was significantly less than the area of "eye of lean" in Lot III, but the difference between the former Group and Lot I or Lot II was not significant (Appendix - Table VII).

It may be seen that there was only a negligible difference in the area of "eye of lean" shown for Lot I and Lot II, the two Lots which were fed "outside".

In other words, with respect to size of "eye of lean", there was no significant difference between the animals which were fed inside and those which were fed outside, and with respect to the two groups which were fed outside and received an unlimited amount of exercise, a significant difference in size of eye of lean was not apparent. However, there was a significant difference between the two groups which were fed under inside conditions, the group which received the mixed protein supplement showing the least area of "eye of lean".

There was not a significant difference in "percentage eye of lean in cross-section" between the two "inside" fed groups or between the two lots which were fed outside. Furthermore, there was not a significant difference in the percentage eye of lean in cross-section between the two "inside" fed groups and the two which were fed "outside". (Appendix - Table VIII).

With respect to percentage total lean in the cross-section, it was found that there was no significant difference between the two "inside" fed groups or between the two "outside" fed groups. Furthermore, when the percentage for

all of the animals in Lots I and II were compared with those in Lots III and IV, it was found that the difference between the "inside" fed animals and those which were fed "outside" was not significant (Appendix - Table IX). However, there was a significant difference between Lot II which was fed "outside", and Lot IV which was fed "inside".

There was no significant differences in size of "eye of lean", percentage eye of lean in cross-section or percentage total lean in cross-section, between the groups which were fed "inside" and those which were fed "outside". This seems to indicate quite clearly that a system of "outside" feeding where conditions are such that unlimited exercise may be taken by the animal, is not conducive to the production of a leaner carcass.

It has been shown previously that in the case of the "outside" fed groups, there was not a significant difference in the detailed measurements between the animals which received skim-milk and those which were fed a mixed protein supplement. On the other hand, Lot IV, the "inside" fed group which received the mixed protein supplement, showed a significantly smaller "eye of lean" than did Lot III, which received skim-milk. It seems likely that any influence on carcass quality which the feeding of protein supplements may have, would be more pronounced under condition of "inside" feeding than where the animals are fed "outside" and have access to green forage. This possibility must be kept in mind. However, in view of the fact that the percentage total

lean in cross-section for Lot IV was not significantly less than the percentage total lean in cross-section for Lot III, it would appear that feeding skim-milk even under conditions of "inside" feeding did not significantly influence the amount of lean in the carcasses.

EXPERIMENT NO. III. (WINTER 1936-37)

The Influence of Methods of Feeding on Growth and Carcass Quality:

Objects of the Experiment:

The objects of this experiment may be stated as follows:-

1. To note the effect of different planes of nutrition at different stages of maturity on the growth of swine.

2. To determine the influence of such planes of nutrition on the quality of the carcass.

Animals Used:

Three groups, each including six purebred Yorkshire pigs were used in this experiment. The animals were allotted to the different groups on the litter mate basis in order to secure as high a degree of uniformity as possible.

Arrangement of Groups:

The following plan was followed in arranging the groups:

Lot I: Standard Ration - full-fed entire experiment.

Lot II: Standard Ration - full-fed to 150 pounds, balance *limited-fed.

Lot III: Standard Ration - *limited-fed up to 150 lbs., balance full-fed.

*The limited-fed animals received approximately 2/3 full feed.

Feed:

Grain Mixture:

The grain mixture consisted of ground oats, barley and wheat in the following proportions:-

	Weaning to 110 lbs.	110 lbs. to Market Wt.
Oats (3CW)	30	10
Barley (3CW)	50	60
Wheat (5N)	20	30

Protein Supplement:

The protein supplement was made up as follows:-

Tankage	50 lbs.
Linseed oil meal	25 "
Fish meal	15 "
Ground limestone	5 "
Salt	5 "

This mixture was added to the grain at the rate of 15% until the pigs reached a weight of 110 pounds, after which it was fed at the rate of 10%.

Cod Liver Oil:

Cod liver oil of good poultry grade was fed at the rate of one pound, added to each 100 pounds of grain and supplemental mixture, until the pigs reached a weight of 110 pounds.

Methods of Feeding:

All Lots were fed three times daily, the grain being slopped with water before feeding.

Shelter:

The pigs were sheltered in a shed type of piggery and were confined to pens 8' by 10' in size during the period of the experiment.

Discussion of Methods of Feeding:

It is quite conceivable that different methods of feeding whereby animals are subjected to different planes of nutrition at various stages of maturity, may influence the physiological phenomenon called growth. That is the "growth curve" for an animal which is held on a restricted diet for a period of time will likely be different to the "growth curve" for one which is full-fed throughout the duration of the feeding period.

If the growth of an animal is influence to any great extent, it would seem that this might well be reflected in the quality of the carcass. Such features as the length of the carcass, thickness of belly and the proportion of lean to fat may be influenced by using different planes of nutrition at different stages of growth.

Results of Experiment No. III.

Table VIII. Average Daily Gains.

	Lot I	Lot II	Lot III
	Full-fed Weaning to market wt.	Full-fed to 150 lbs. Balance limited	Limited-fed to 150 lbs. Balance full-fed.
Av. Initial Weight	40.17 lbs.	40.06 lbs.	41.17 lbs.
No. of Days on Expt.	115.0	129.0	135.0
Av. Final Weight	211.7 lbs.	207.3 lbs.	206.7 lbs.
Av. Daily Gain	1.49 "	1.29 "	1.22 "

A survey of the data presented in the above table shows that Lot I had a margin of 0.20 lbs. in average daily gain over Lot II, the next highest group. This is quite in ac-

cordance with expectations as this group was full-fed throughout the duration of the experiment while both Lots II and III were limited-fed part time. Lot II, the group which was full-fed up to 150 lbs. and then limited-fed until they reached market weight, showed a slightly higher average daily gain than Lot III which was limited fed up to 150 lbs. and then full-fed until the individuals reached market weight.

It may be noted that Lot I was on experiment 14 days less than Lot II, while the animals in Lot III required on the average 6 days more to reach market weight than did those in the No. II Group.

While the figures presented above show quite clearly how the groups compared with regard to average daily gains, they do not show when or at what stage of maturity the gains were greatest.

However, this appears to be brought out reasonably well by the graphs shown on Plates III and IV.

The graphs showing the gains for the individual animals over 14-day periods indicate a large degree of uniformity within each group.

The individuals in Lot I showed a gradual and consistent increase in rate of gain from the time they went on feed until the experiment was concluded.

Up until the time the plane of nutrition was lowered, the animals in Lot II made gains very similar to those in Lot I. From that time on, however, the gains were somewhat lower.

The Lot III animals showed very low gains while on the

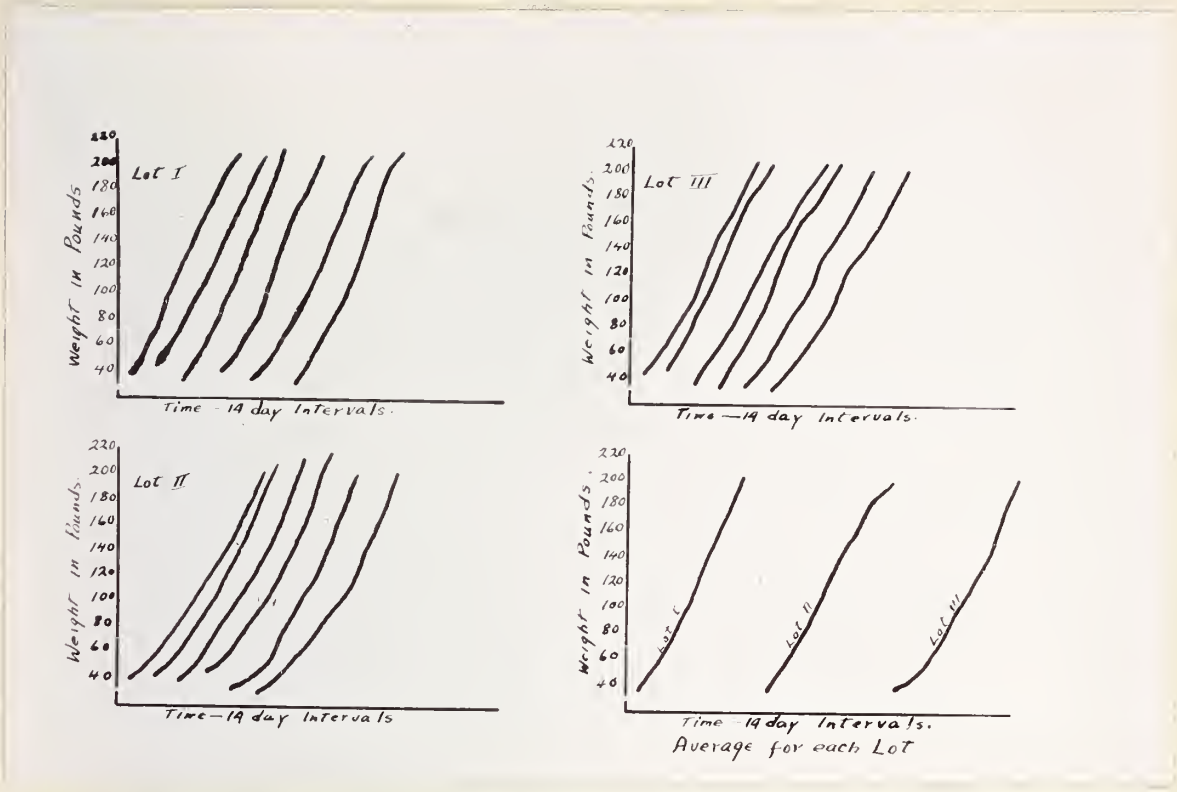

Plate III: Showing the Rate of Growth of Individuals in the Respective Lots, and the Average Rate of Growth for Each Lot in Experiment III.

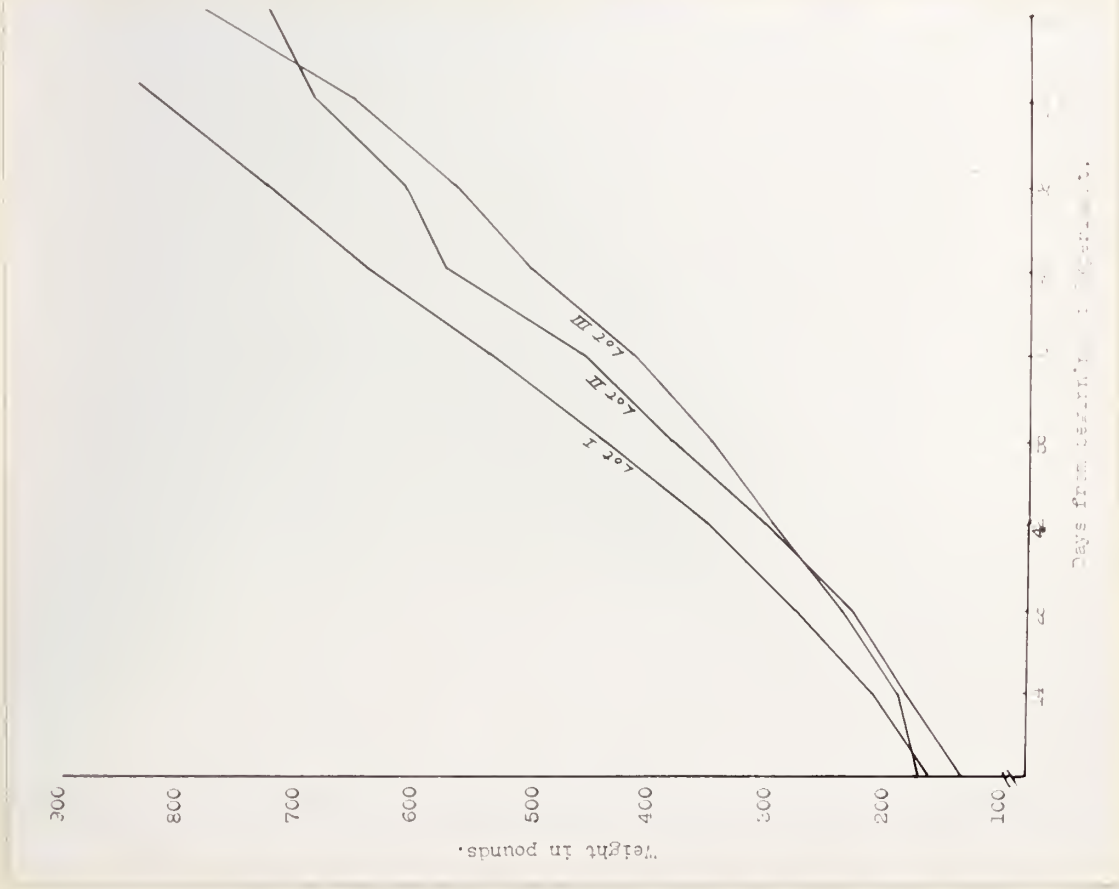

Plate IV: Showing the increase in total live weight of four individuals in each Lot, in Experiment III.

low plane of nutrition, but some individuals made what could be considered as phenomenal gains after the plane of nutrition was raised. Graphs illustrating the average gains made by the various lots also follow similar respective trends as those showing the individual gains.

Quality of Carcasses:

Similar measurements to those used in Experiment I, were made on all carcasses, and the figures are shown in the following table:-

Table IX. Measurements and Percentage Cuts of Carcasses.

	Lot I	Lot II	Lot III
Av. Length of Carcass (inches)	30.8	30.7	30.5
% Shoulder of Carcass	27.6	29.3	29.3
% Ham of Carcass	24.8	25.0	25.3
Av. Depth of Shoulder Fat (inches)	1.8	1.9	1.8
Av. Depth of Back Fat (inches)	1.0	0.9	1.0
Av. Depth of Loin Fat (inches)	1.5	1.3	1.3
Av. Min. Belly Thickness (inches)	1.0	0.9	0.8
Av. Max. Belly Thickness (inches)	1.7	1.8	1.6

It has been shown that there were no significant differences in length of carcass between the respective groups of animals. (Appendix - Table X). Thus the different planes of nutrition did not exert any significant influence on the length of the carcass.

Lot I, the lot which was full-fed throughout the duration of the experiment, showed a significantly less percentage shoulder of carcass than Lot II and Lot III. There was not a significant difference between Lot II and Lot III. (Appendix - Table XI).

The smaller percentage of shoulder shown by Lot I might be due to some extent at least to the slightly heavier "finish" over the loin and greater thickness of belly shown by this group. These features would tend to increase the weight and consequent percentage "middle" which might well result in a decrease in percentage shoulder. Notwithstanding this, it should be pointed out that the average weight of the shoulders for Lot I was less than those for Lots II and III respectively.

The above results indicate that limiting the amount of feed allowed the animals either during the first part or the latter part of the feeding period may be a factor in the production of carcasses carrying a higher percentage of shoulder than carcasses yielded by pigs which are full-fed throughout the entire experiment.

The amount of "finish" carried by the animals in Lot I, as determined by shoulder, back, and loin fat measurements, was slightly though not significantly greater than that shown by the other two groups. (Appendix - Table XII).

The "limited-fed" groups, particularly Lot III which was limited-fed up to 150 pounds, were deficient in "belly thickness" as indicated both by the measurements and grading.

Detailed Carcass Measurements:

Detailed measurements were made on rashers taken from all carcasses, in a similar manner to those taken in the previous experiments.

Table X. Detailed Carcass Measurements.

	Lot I	Lot II	Lot III
Av. Total Area of Cross-section (sq. in.)	25.25	24.17	22.17
Av. Area of "eye of lean" (sq. in.)	4.17	4.23	4.60
% "eye of lean" in Cross-section	16.55	17.51	20.23
% Total lean in Cross-section	39.45	40.53	42.70

While it may be seen from this table that there were some differences between the three lots with respect to both size of "eye of lean" and percentage total lean in cross-section, it has been shown that such differences were not statistically significant. (Appendix - Tables XIII and XIV).

It is of some significance to note the various Official Carcass Grades placed on the carcasses yielded by the animals from the respective groups. This grading was done by an Official of the Dominion Department of Agriculture and the Grades allotted are shown below. The figures indicate the number of carcasses receiving a certain grade.

Belly Grade:

	Lot I	Lot II	Lot III
"Excellent"	1	---	---
"Good"	4	4	3
"Fair"	1	2	3

Wiltshire Grade:

"Leanest Lean" (the highest grade)	6	6	6

Wiltshire Class:

Class I	5	4	2
Class II	1	2	4

While the grading results presented above are somewhat arbitrary, they do bear out the finding presented previously in as much as they show a somewhat poorer belly grade for the two groups of pigs which were limited fed, particularly Lot III. The lower Wiltshire Class shown for the individual animals from these two groups is doubtless largely due to the lack of sufficient "belly thickness".

Firmness of Carcasses:

In order to determine whether or not different methods of feeding had any influence on the firmness of the carcass, Iodine Numbers were determined on samples of back fat from all carcasses. The average Iodine Numbers for the respective Lots were found to be as follows:-

	Lot I	Lot II	Lot III
Av. Iodine Number	62.1	61.2	62.1

It may be seen from these figures that the different methods of feeding as carried out in this experiment did not have any significant influence on the firmness of the fat in the carcass.

EXPERIMENT NO. IV. (WINTER 1939-40).

The Influence of Methods of Feeding on Carcass Quality.

This experiment was not an exact duplicate of Experiment No. III, but it was outlined with a view to securing further data and information on the influence of methods of feeding on carcass quality. The general outline of the experiment was

very similar to that of the previous experiment but more details were included.

The objects of the experiment may be enumerated in the following manner.

1. To study the influence of feed intake and rate of growth on the proportions and composition of the carcass.

2. To compare "limited" with "full" feeding from the standpoint of influence on percentage of fat and lean in the carcass and on general "finish".

3. To compare light and heavy feeding during the latter part of the feeding period on the above mentioned features.

Animals Used:

Eight pigs were included in each of three groups. Five animals in each group were purebred Yorkshires and the remaining three were Tamworths by Yorkshire cross-breds. The groups were allotted in so far as possible on the "litter mate" basis, and consideration was given to size, condition and general thrift.

Arrangement of Groups:

The groups were arranged according to the following plan:-

Lot I: Standard A.R. Ration - full-fed entire experiment.

Lot II: Standard A.R. Ration - full-fed first period to 140 lbs. - balance *limited-fed.

Lot III: Standard A.R. Ration - *limited-fed first period to 140 lbs. - balance full-fed.

*Limited-fed groups received slightly less than 2/3 full-feed.

Feed.

Grain Mixture:

The grain mixture was similar to that used in the previous experiment.

Protein Supplement:

The same protein supplement, fed at similar rates as in Experiment III, was again used.

Cod Liver Oil:

Cod liver oil was fed at the rate of one pound to each 100 pounds of grain and supplemental mixture until the pigs reached the weight of 110 pounds.

Methods of Feeding:

All Lots were again hand fed three times daily, the grain being slopped with water before feeding.

Shelter:

Similar shelter to that outlined in the previous experiment was again provided.

Discussion of Methods of the Experiment:

As was pointed out previously, this experiment was outlined primarily with a view to checking the results secured in Experiment III, but an attempt was also made to secure more detailed data regarding the "growth" of the animals on the different planes of nutrition.

Lot I was carried on full-feed throughout the duration of the experiment.

Lot II was similarly carried on a full-feed until the average weight of the animals in the group was approximately

140 pounds, after which time the ration was limited to slightly less than two-thirds full-feed.

Lot III received "limited-feed" only until the average weight of the individuals was approximately 140 pounds. This lot then received "full-feed" until the end of the feeding period.

In order to determine whether or not there were any differences in the proportion and composition of the carcasses from the different groups at earlier stages of maturity, two individuals from each group were slaughtered immediately prior to the change in plane of nutrition. The remaining six pigs in each group were slaughtered at weights ranging from 200 to 210 pounds.

In this manner, a comparison was made of carcasses yielded by individuals at different stages of maturity "within groups" and of carcasses yielded by individuals at approximately the same stage of maturity "between groups".

Results of Experiment No. IV.

Average Daily Gains.

The average daily gains of the three respective groups from the beginning of the experiment up until the time that two individuals were removed from each group and the planes of nutrition in Lots II and III were changed, are shown in the following table:-

Table XI. *Average Daily Gains up to the Time Planes of Nutrition were Changed.

	Lot I	Lot II	Lot III
Av. Initial Weight	48.0 lbs.	46.5 lbs.	45.3 lbs.
Av. No. of Days on Experiment up until end of Period	76	76	104
Av. Weight at end of Period	148.2 lbs.	146.8 lbs.	139.4 lbs.
Av. Daily Gain	1.32 "	1.32 "	0.90 "

*Average Daily Gains based on eight individuals in each group.

The purpose of this table is to illustrate the uniformity in average daily gains between Lot I and Lot II, and to emphasize the comparatively low average daily gain exhibited by the limited-fed group, namely Lot III.

Plate V illustrates the growth rates for the individuals in the respective Lots and the average growth rate for each of the three Lots. A certain lack of uniformity within Lot III may be noted. The graphs showing the average growth rate for each of the Lots corroborates the figures presented in the above table.

Plate VI shows the total weight increase and the number of days on experiment up until two individuals were removed from each group, for the three Lots respectively.

Carcass Data:

As was stated previously, two animals were removed from each group immediately prior to the change in plane of nutrition. It will be noted that two individuals were removed from Lot I although this group was kept on the same plane of nutrition throughout the duration of the experiment.

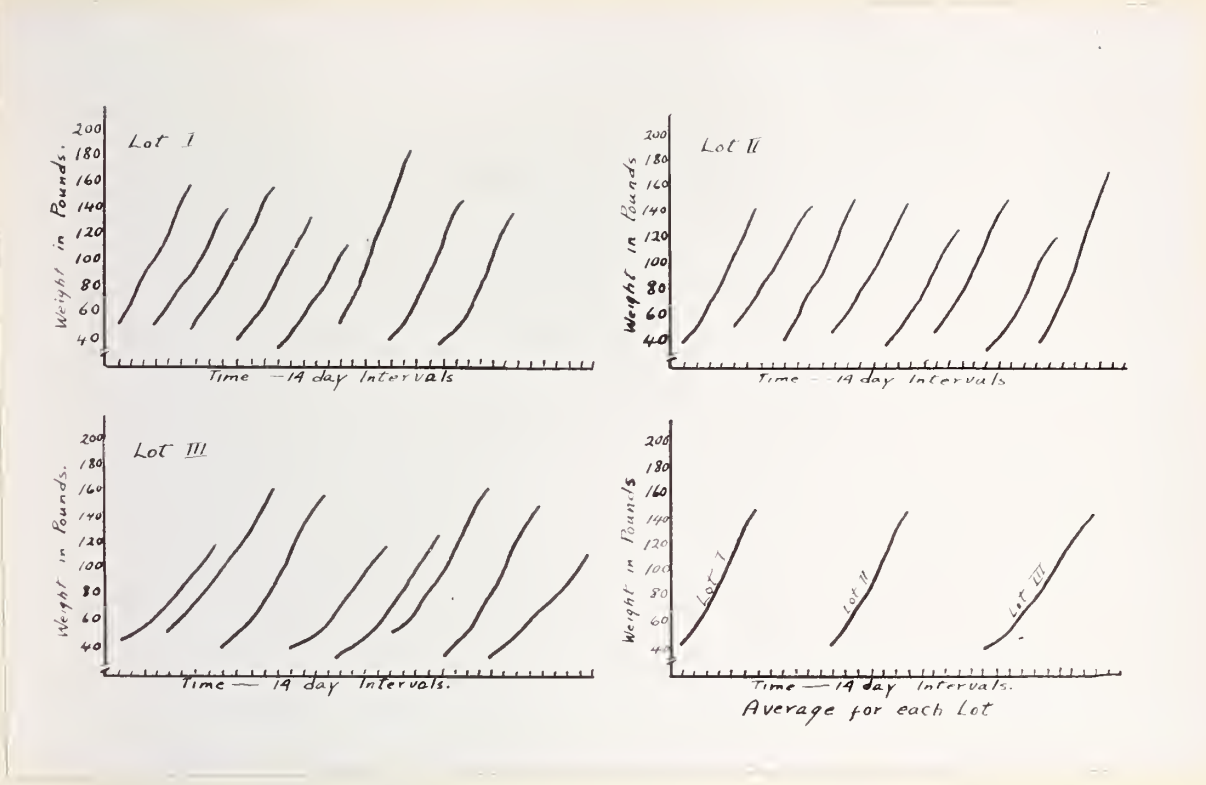

Plate V: Illustrating the Rate of Growth of the Individuals in the Respective Lots, and the Average Rate of Growth in Each Lot in Experiment IV.

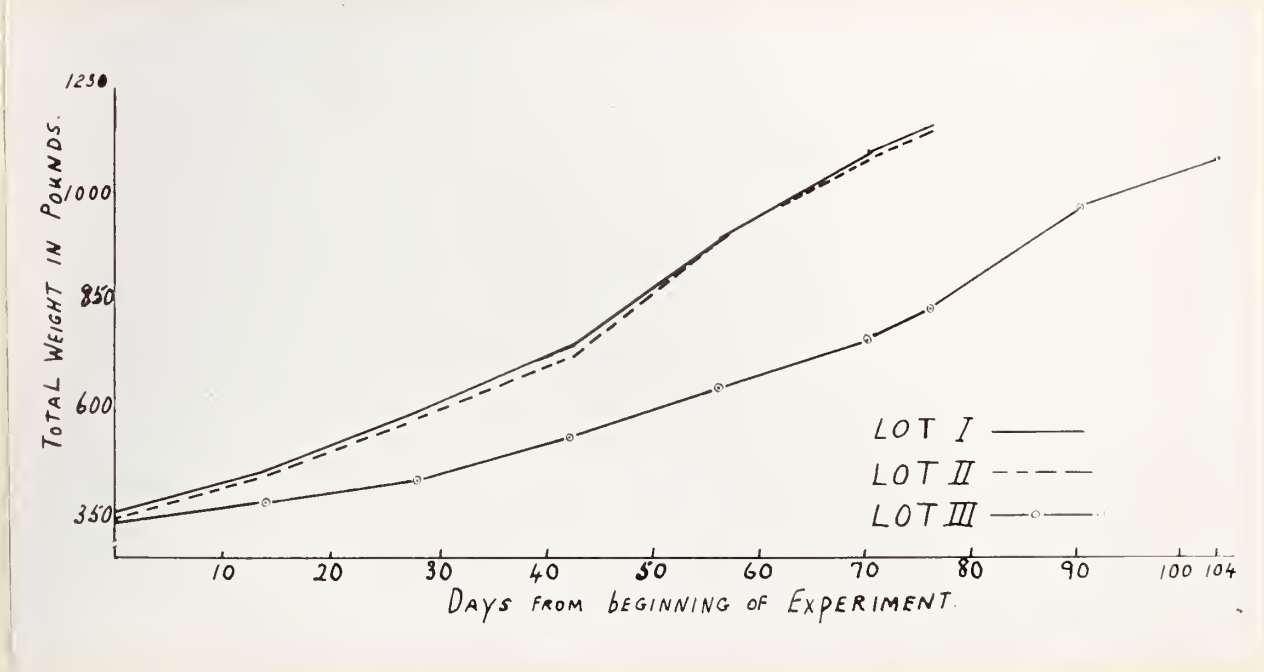

Plate VI: Showing Total Weight Increase of Each Lot from beginning of the experiment up until two animals were removed from Each Lot.

The purpose of this was primarily to keep all the groups on a comparable basis, and it also served as a check on Lot II, from the standpoint of carcass measurements and proportions.

A "Between Group" Comparison of Carcasses:

A comparison of the carcasses yielded by the animals which were slaughtered before the change in plane of nutrition took place was made, and the relevant data are presented in Table XII.

The data presented in Table XII indicate that the animals which were "limited-fed" produced carcasses showing a somewhat higher percentage of shoulder and lower percentage of ham than those yielded by the "full-fed" animals. Lot III, the "limited-fed" group, showed less depth of fat over the shoulder, but compared favorably with Lots I and II with respect to depth of loin fat and back fat respectively. The "full-fed" animals showed a somewhat greater "thickness of belly" than those which received only a limited amount of feed.

Detailed Carcass Measurements:

Detailed measurements were made on rashers taken from the carcasses of the six animals which were slaughtered prior to the changes in plane of nutrition being made. The average measurements are shown in Table XIII.

It may be observed that the animals from Lot III, the group which was "limited-fed" up to 140 pounds, showed the largest "eye of lean", the highest percentage "eye of lean" in cross-section, and the highest percentage total lean in

Table XII. Carcass Measurements and Proportions.

	Lot I			Lot II			Lot III		
	Full-fed entire period			Full-fed up to 140 lbs. Balance Limited-fed			Limited-fed up to 140 lbs. Balance Full-fed		
	Animal No. 1	Animal No. 2	Average	Animal No. 1	Animal No. 2	Average	Animal No. 1	Animal No. 2	Average
Cold Carcass Weight (lbs.)	93.0	106.5	99.8	89.5	103.0	96.2	89.0	107.0	98.0
Av. Length of Carcass (inches)	26.4	26.8	26.6	26.6	26.2	26.4	26.2	27.6	26.9
% Shoulder of Carcass	27.48	27.62	27.55	28.49	29.01	28.75	30.19	30.78	30.48
% Ham of Carcass	26.37	25.73	26.05	27.04	26.88	26.96	26.59	23.96	25.28
Av. Depth of Shoulder Fat (inches)	1.88	1.25	1.56	1.50	1.50	1.50	1.38	1.38	1.38
Av. Depth of Back Fat (inches)	0.75	0.75	0.75	0.56	1.00	0.78	0.62	0.88	0.75
Av. Depth of Loin Fat (inches)	1.00	1.00	1.00	0.69	1.12	0.90	0.88	1.12	1.00
Av. Min. Belly Thickness (inches)	0.94	0.75	0.84	0.69	0.56	0.62	0.56	0.69	0.62
Av. Max. Belly Thickness (inches)	1.06	1.50	1.28	1.00	0.94	0.97	0.88	1.00	0.94

Table XIII. Detailed Carcass Measurements.

	Lot I	Lot II	Lot III
Av. Total Area of Cross-section (sq. in.)	16.84	16.22	17.89
Av. Area of "eye of lean" (sq. in.)	3.52	3.70	4.14
% "eye of lean" in cross-section	21.12	22.79	23.16
% Total lean in cross-section	42.78	46.04	48.48

cross section. These results indicate, in so far as the percentage total lean in the cross-section is an index of the proportion of lean in the carcass, that the "limited-fed" animals yielded carcasses which contained a higher proportion of lean to fat than the carcasses yielded by the "full-fed" animals.

It would thus appear that limited-feeding did not adversely affect the production of lean meat up to the stage at which these pigs were slaughtered.

A Further Comparison Between Groups:

It has been stated previously that six animals in each group were kept on experiment until they reached market weight. A comparison between the groups with regard to rate of gain and quality of carcass produced was made on the basis of the six individuals in each group, and the data will now be presented.

Table XIV. Average Daily Gains.

	Lot I Full-fed entire period	Lot II Full-fed to 140 lbs. Balance Limited-fed	Lot III Limited-fed to 140 lbs. Balance Full-fed
Av. Initial Weight	49.39 lbs.	48.06 lbs.	47.67 lbs.
Av. No. of Days on Expt.	113.0	132.0	134.0
Av. Final Weight	210.17 lbs.	206.33 lbs.	204.50 lbs.
Av. Daily Gain	1.42 "	1.20 "	1.17 "

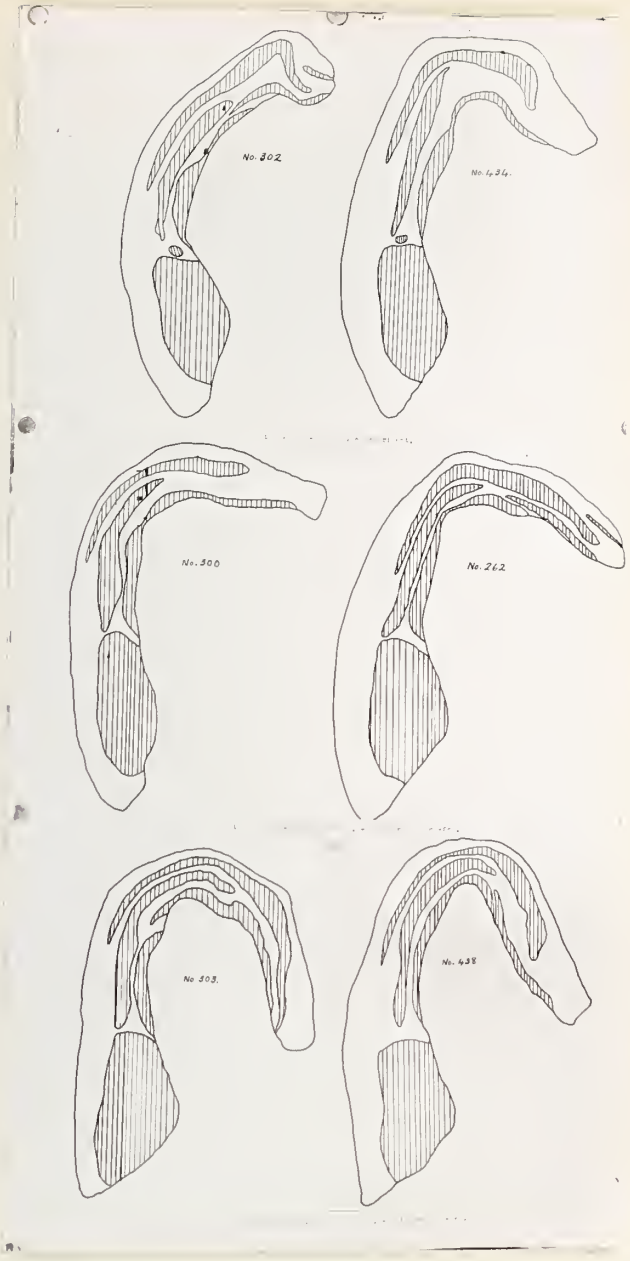

Plate VII: Illustrating Cross-Sections taken from the carcasses yielded by the animals which were removed from the Experiment and slaughtered before the changes in plane of nutrition were made.

These figures indicate that while the average daily gains for the respective lots were slightly lower than those shown for Experiment III (Table VIII), the differences between the lots with respect to average daily gain were very similar to those of the previous experiment.

Lot I was on experiment 19 days less than Lot II and 17 days less than Lot III. There was a difference of only 2 days in the time required to reach market weight between Lot II and Lot III.

It may be recalled that the animals in Lot III required an average of 28 days longer than those in Lot II to reach an average weight approximating 140 pounds, and yet it required only 2 days longer for them to reach market weight.

This indicates that the growth of the Lot III animals was distinctly retarded for the first period, and that rapid growth took place during the latter part of the feeding period.

On the other hand, the Lot II animals reached an average weight approximating 140 pounds in the same length of time as those in Lot I and yet they required 19 days longer to reach market weight, thus showing that growth was retarded during the latter part of the feeding period in the case of the Lot II animals.

Plate VIII illustrates graphically the growth of the individuals in the various lots, and the average rate of growth for each lot, for the entire feeding period.

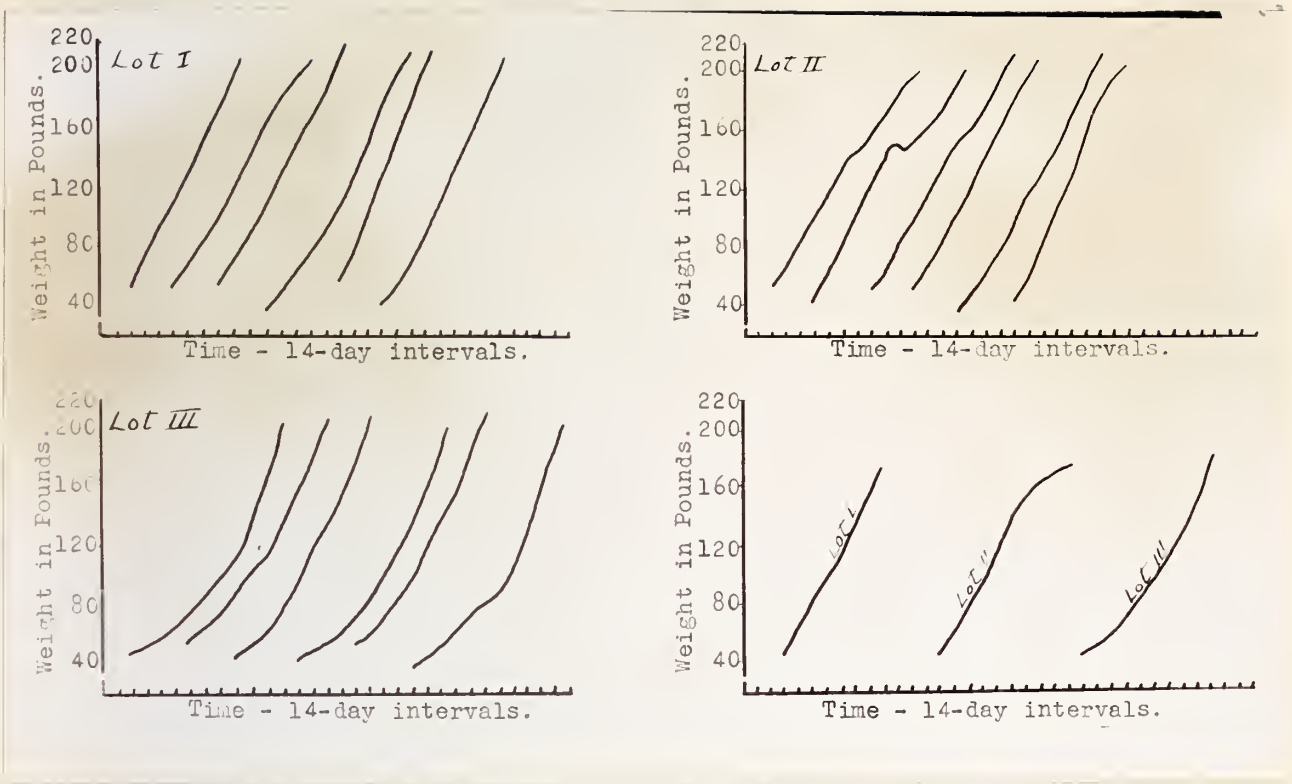

Plate VIII: Showing the Rate of Growth of the six Individuals in the Respective Lots, and the Average Rate of Growth for Each Lot in Experiment IV.

Carcass Quality:

The measurements and proportions of the carcasses yielded by the pigs in the three groups are presented below.

Table XV. Measurements and Percentage Cuts of Carcass.

	Lot I	Lot II	Lot III
Av. Length of Carcass (inches)	30.2	30.0	30.0
% Shoulder of Carcass	28.2	27.4	28.5
% Ham of Carcass	24.5	24.5	24.6
Av. Depth of Shoulder Fat (inches)	2.1	1.8	1.8
Av. Depth of Back Fat (inches)	1.3	1.0	1.1
Av. Depth of Loin Fat (inches)	1.5	1.4	1.5
Av. Min. Belly Thickness (inches)	0.9	1.0	0.8
Av. Max. Belly Thickness (inches)	1.7	1.8	1.5

There were no significant differences between the groups with respect to length of carcass (Appendix - Table XV). This bears out the findings in the previous experiment, and shows quite definitely that subjecting the animals to the different planes of nutrition indicated, did not significantly influence the length of the carcasses yielded.

The differences between the groups with respect to percentage shoulder of carcass were not statistically significant (Appendix - Table XVI). This does not bear out the results secured in Experiment III, which indicated that the carcasses yielded by the pigs which were "full-fed" for the entire experiment carried a significantly less percentage of shoulder than the carcasses yielded by the animals which were "limited-fed". However, it must be borne in mind that the significant difference shown in Experiment III may have been due to chance alone. On the basis of the results of the two experiments, it

cannot be concluded that subjecting the animals to different planes of nutrition had any significant influence on the percentage shoulder of carcass.

With regard to the amount of "finish" carried by the animals in the respective groups, it may be noted that Lot I showed a somewhat greater average depth of shoulder fat and back fat than did either Lot II or Lot III. However, in so far as these results are not consistent with those obtained in the previous experiment, it cannot be definitely concluded that the slightly higher figures shown for Lot I in this experiment were due to the influence of the planes of nutrition to which the respective groups were subjected.

The carcasses yielded by the animals in Lot III were lacking in "belly thickness" as compared with those yielded by the animals in Lots I and II respectively. This bears out the results obtained in Experiment III, and indicates that the animals which were "limited-fed" for the first part of the feeding period produced carcasses which lacked sufficient "belly thickness".

For purposes of comparing the respective lots with reference to "depth of fat" and "belly thickness" measurements, the results obtained for both Experiments III and IV have been averaged and are presented in the next table.

These results based on the outcome of both Experiments III and IV indicate that the animals which were "full-fed" for the entire feeding period carried a slightly heavier "finish" as indicated by shoulder, back and loin fat measure-

Table XVI. Average Measurements for "Depth of Fat" and "Thickness of Belly" (Experiments III and IV).

	Lot I	Lot II	Lot III
Av. Depth of Shoulder Fat (inches)	2.0	1.8	1.8
Av. Depth of Back Fat (inches)	1.2	1.0	1.0
Av. Depth of Loin Fat (inches)	1.5	1.4	1.4
Av. Min. Belly Thickness (inches)	1.0	1.0	0.8
Av. Max. Belly Thickness (inches)	1.7	1.8	1.6

ments. There was no difference in this regard between the animals which were "limited-fed" for the first period and those which were "limited-fed" during the latter part of the feeding period.

On the other hand, Lot III which was "limited-fed" during the first period, showed a lower "thickness of belly" measurement than either of the other two groups.

A "Belly Grade", similar to that referred to in the previous experiment, was again secured on each of the carcasses. The results are shown below, the figures indicating the number of carcasses receiving a certain grade.

Belly Grade.

	Lot I	Lot II	Lot III
"Excellent"	3	1	1
"Good"	2	3	2
"Fair"	1	2	3

In order to give a more definite rating to the different carcasses, an attempt was made to score them on the following basis: a carcass graded as "excellent" was allotted 10 points, one graded as "good" 7 points and one graded as "fair" 4 points. On this basis the scores for the respective lots were as

follows:-

Lot I	Lot II	Lot III
48	39	36

This system of scoring the carcasses with regard to "belly grade" is purely arbitrary, but it does appear to indicate the relative merits of the carcasses from this standpoint. It is quite obvious that the "limited-fed" groups had lower scores than the "full-fed" group, thus indicating the superior quality of "belly" in the carcasses yielded by the "full-fed" animals. There was little difference in "belly grade" between the carcasses yielded by the animals which were "full-fed" for the first period and those which received only a limited amount of feed during that period.

Detailed Carcass Measurements:

It must be pointed out at this time that due to unavoidable circumstances, some of the cross-sections from the carcasses yielded by the animals in this experiment were lost while at the Packing Plant, and therefore detailed measurements could not be made on them. This so reduced the number of cross-sections from some of the lots, that an interpretation of the data with regard to detailed measurements was impossible.

However, measurements of the "eye of lean" in each of the cross-sections had been made previously. These measurements represent the length and the width of the "eye of lean", and are included in the Official Score used in connection with the Advanced Registry for swine.

While such measurements are not strictly comparable with measurements made with a planimeter as in the other experiments, they serve as a means of comparing the size of "eye of lean" in the carcasses yielded by the respective groups in this experiment. Furthermore, it seems quite probable as suggestedby Stothart (44) that the size of the "eye of lean" is an index to the amount of lean in the carcass.

The average area of the "eye of lean", as determined by "length x width", for the three lots of animals, is shown below.

	Lot I	Lot II	Lot III
Av. Area of "Eye of Lean" (sq. in.)	5.67	5.99	6.25

It has been shown (Appendix - Table XVII) that the differences in area of "eye of lean" between the groups were not statistically significant. This bears out the results obtained in Experiment III which indicated that while some differences with respect to size of "eye of lean" existed between the groups of animals, such differences were not great enough to be statistically significant.

It would thus appear that limiting the amount of feed within the limits outlined in this and the preceding experiments, either during the early or late stages of the feeding period, did not significantly influence the size of the "eye of lean" in the carcasses yielded.

In so far as the area of the "eye of lean" can be taken as an index of the amount of lean in the carcass, the above

results indicate that there were no significant differences between the respective groups with regard to percentage total lean in the carcass. This again qualifies the findings in this regard in Experiment III.

A "Within Group" Comparison of the Carcass Data:

A comparison was made between the carcass data on those pigs which were slaughtered previous to the change in plane of nutrition, and those which were kept on experiment until they reached market weight.

In as much as the differences between the respective lots, particularly in the case of the animals which were slaughtered previous to the change in plane of nutrition, were based on such a small number of animals, little in the way of definite conclusions regarding the influence of the different planes of nutrition on the quality of the carcasses within a group could be drawn. However, some observations were made.

The animals which were slaughtered previous to the change in plane of nutrition produced carcasses carrying a higher percentage of ham than those yielded by the animals which were not slaughtered until they reached market weight. This was found to be the case in each of the three groups, and therefore the difference cannot be explained on the basis of the different planes of nutrition. It may be that as the pig matures, other portions of the body develop more rapidly than that portion designated as ham, thus resulting in a less percentage of ham in the carcasses yielded by the more

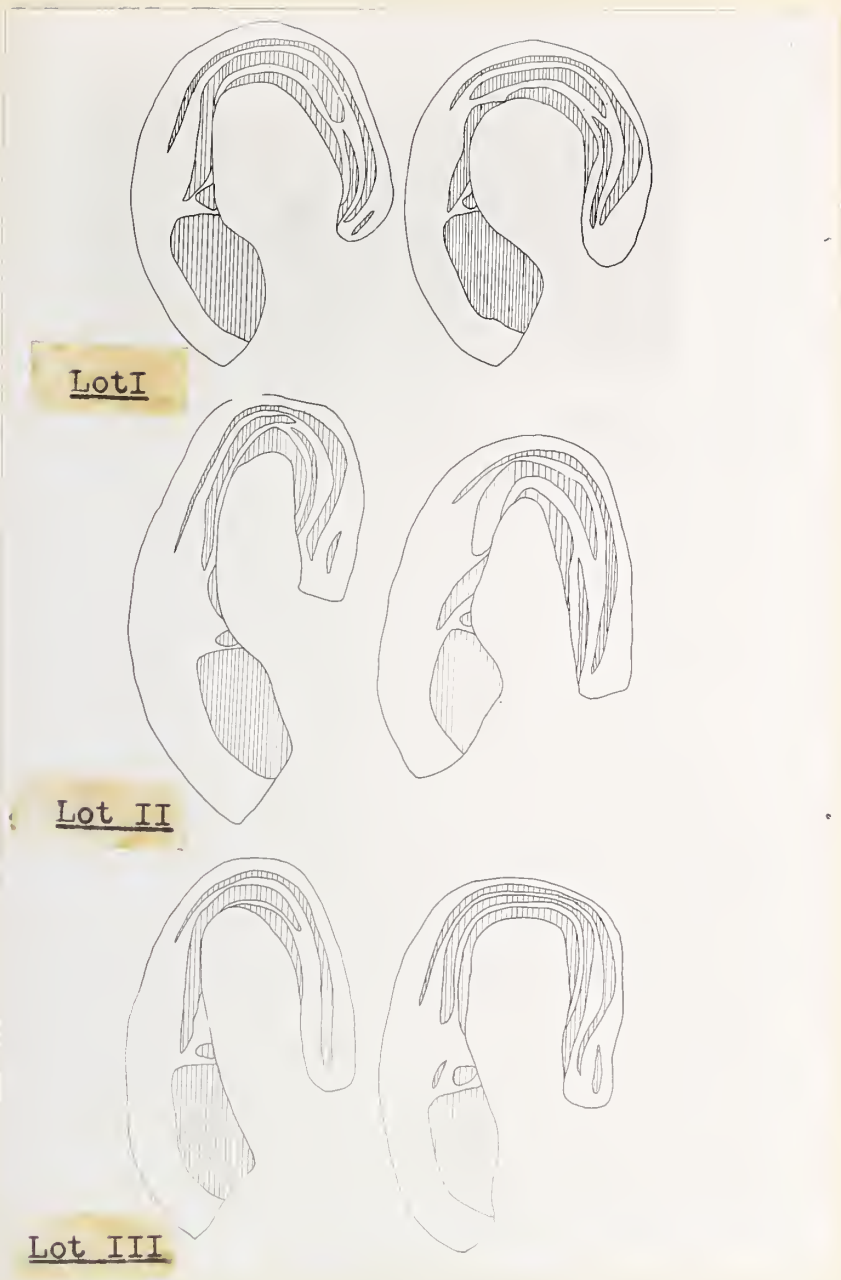

Plate IX: Illustrating Cross-Sections taken from the Carcasses of animals in Experiment IV which were allowed to reach market weight, before being slaughtered.

mature animals.

The carcasses yielded by the animals which were "limited-fed" during the first period were deficient in "belly thickness". This undesirable feature was evident in the carcasses yielded by the Lot III animals which were slaughtered previous to the change in plane of nutrition and continued to manifest itself in the carcasses from those animals in Lot III which were "full-fed" for the remainder of the feeding period.

In general, with regard to the influence of different planes of nutrition at different stages of growth, on the quality of carcass produced, the results of Experiments III and IV, while not altogether consistent, indicated that the animals which were on "full-feed" for the entire feeding period carried a slightly greater amount of "finish" than the animals which were "limited-fed". On the other hand, the animals which were "limited-fed" for the first period, and then "full-fed" to market weight, failed to develop sufficient "thickness of belly".

In so far as Lot I showed the least, and Lot III the greatest percentage lean in the carcass as determined by detailed measurements of the cross-sections, the above results were borne out in this regard. However, it has been stated previously, that the differences in percentage lean in the carcasses as determined by detailed measurements, between the respective lots, were not statistically significant.

One plausible explanation for this discrepancy would seem to be that any such differences in detailed measurements were not sufficiently great to show a statistical difference when only a very small number of individuals were used in the experiments.

EXPERIMENT NO. V. (WINTER 1936-37).

The Influence of Temperature on the Growth of Swine and on the General Carcass Quality with Particular Reference to the Firmness of Fat in the Pig Carcass:

Animals Used:

Three groups of five purebred Yorkshire pigs were used. The animals were allotted on the "litter mate" basis and in this way a relatively high degree of uniformity at the beginning of the experiment was secured.

Arrangement of Groups and Methods of Housing:

The arrangement of the Experimental Groups was as follows:-

Lot I: Standard A.R. Ration - Swine Barn, Heated.

Lot II: Standard A.R. Ration - Swine Barn, No heat.

Lot III: Standard A.R. Ration - Colony House, Fed outside.

The main object of this experiment was to study the effect of the temperatures to which the growing bacon hog is subjected on the rate of growth of the animal and on the firmness of fat in the carcass. This being the case, the three groups of pigs were housed under different temperature

conditions. As shown above, Lots I and II were housed in the main swine barn at the University Farm, Lot I in a section of the barn provided with heat from a small stove, and Lot II in a section without artificial heat. Lot III was sheltered in a colony house, 6' by 8' which was banked with straw to the eaves.

The temperatures in the three shelters were recorded daily at 8 a.m. and 5 p.m. during the period from December 9th to March 24th. On the average the temperature in the heated section of the barn was maintained approximately 20 degrees above that in the unheated section, while the temperature in the colony house was on the average almost the same as that in the unheated portion of the barn. The temperature varied considerably from day to day, particularly in the two shelters which were not provided with artificial heat.

The averages of the daily temperatures ranging over approximately the first and second half respectively of the consecutive months during which the experiment was in progress, are shown in the following table. The temperatures for the period from December 9th to December 15th were included along with those for the latter half of December. The average temperature in each shelter for the entire period December 9th to March 24th is also shown.

That section of the swine barn which was heated was kept dry and free from frost during the entire winter. In the unheated portion frost accumulated during the colder spells of weather and melted when milder weather occurred.

Table XVII. Temperatures in Shelters.

Av. Temp. in Shelters:	Lot I Hog Barn Heated	Lot II Hog Barn Unheated	Lot III Colony House
December 9 - 31	45.6°F.	31.5°F.	25.9°F.
January 1 - 15	36.9	21.5	18.9
January 15 - 31	42.3	17.9	20.8
February 1 - 14	48.0	22.6	28.9
February 14 - 28	51.6	28.9	28.1
March 1 - 15	52.8	41.9	41.9
March 15 - 24	52.2	34.9	37.9
Av. Dec. 9 - Mar. 24	46.6	28.3	29.3

Feeds and Methods of Feeding:

Grain Mixture:

The grain mixture fed was similar to that in the previous experiments.

Supplement:

The following supplement was added to the grain at the rate of 15% during the first period and 10% during the second period:-

Tankage	50 lbs.
Fish Meal	15 "
Linseed Oil Meal	25 "
Ground Limestone	5 "
Salt	5 "
Total	100 lbs.

Cod Liver Oil:

Cod liver oil of a good grade was fed at the rate of one pound added to each 100 pounds of the grain and supplement mixture until the pigs reached an average weight of 110 pounds.

Hand Feeding:

The pigs were hand fed three times daily during the

period of the experiment, the feed mixture being slopped with water before feeding.

Results of Experiment No. V.

Table XVIII. Average Daily Gains.

	Lot I	Lot II	Lot III
Av. Initial Weight	43.7 lbs.	41.6 lbs.	41.9 lbs.
Av. No. of Days on Expt.	112	115	128
Av. Final Weight	212.0 lbs.	207.8 lbs.	207.0 lbs.
Av. Daily Gain	1.50 "	1.44 "	1.29 "

The figures in this table serve to indicate that there was very little difference in the average daily gain or in the number of days on experiment between Lot I which was housed in the heated portion of the swine barn and Lot II which was kept in the unheated section. It would appear that the average lower temperature (approximately 20°F.) did not have any deleterious effects on the growth of the animals in Lot II.

It will be noted that Lot III showed an average daily gain of 1.29 pounds which is 0.15 pounds below that of Lot II and required 15 days longer to reach market weight. This cannot be attributed to the lower temperature condition because, as has already been pointed out, the temperature in the shelter in which Lot III was housed was, on the average, much the same as that of the unheated portion of the barn. It may be, however, that other unfavorable environmental factors such as cold winds and snow which were experienced by this group of animals and not by the other two, would have

their effect. If such be the case, it is extremely important from the practical standpoint.

General Carcass Quality:

Similar measurements to those taken in previous experiments were again recorded.

Table XIX. Measurements and Percentages of the Cuts of Carcasses.

	Lot I	Lot II	Lot III
Av. Length of Carcass (inches)	30.6	30.8	30.7
% Shoulder of Carcass	27.7	28.3	27.9
% Ham of Carcass	24.1	25.0	25.5
Av. Depth of Shoulder Fat (inches)	1.8	2.0	1.8
Av. Depth of Back Fat (inches)	1.1	1.1	1.1
Av. Depth of Loin Fat (inches)	1.6	1.4	1.4
Av. Min. Belly Thickness (inches)	1.0	1.1	1.0
Av. Max. Belly Thickness (inches)	1.8	1.9	1.9

It is apparent from an examination of these figures that there were no significant differences in the average measurements of the carcasses yielded by the pigs in the respective groups.

Detailed Carcass Measurements:

Detailed carcass measurements similar to those in previous experiments were again recorded and are shown in the following table:-

Table XX. Detailed Carcass Measurements.

	Lot I	Lot II	Lot III
Av. Total Area of Cross-section (sq. in.)	26.20	24.59	25.09
Av. Area of "Eye of Lean" (sq. in.)	3.96	4.41	4.31
% "Eye of Lean" in Cross-section	15.13	17.96	17.24
% Total Lean in Cross-section	35.53	40.56	39.21

Detailed Carcass Measurements:

It may be seen that there were some differences in the size of "eye of lean" for the respective groups. However, it has been shown (Appendix - Table XVIII) that the differences were not statistically significant. In other words, the size of the "eye of lean" was not significantly influenced by subjecting the various groups of animals to different temperature levels.

On the other hand, it has been shown that there was a significant difference, significant at the five percent (0.05) point, in the percentage total lean in the cross-section between Lot I, and Lots II and III (Appendix - Table XIX). Lot I showed a significantly lower percentage total lean in cross-section than the other two groups. Although this data indicated that the proportion of lean to fat in the Lot I animals was lower than for Lots II and III, this was not borne out by the fat measurements as shown in Table XIX.

It may of course be that the significant difference obtained for total lean in cross-section was due to chance, and the necessity of conducting further similar trials to prove this point appears to be obvious.

Firmness of Fat:

Two methods were used in arriving at the relative firmness of the fat samples secured from the carcasses of the animals in the different groups. The first was purely a mechanical determination, the firmness of the fat being ascertained by pressing on the fat in the carcass with the

tip of the finger. This determination was made by the Official Grader at the packing plant. There were three gradings -- very firm, firm and fairly firm. The results of the determination are given below.

Table XXI. Fat Grading - Mechanical Determination.

	Lot I	Lot II	Lot III
No. very firm	4	3	2
No. firm	1	1	3
No. fairly firm	-	1	-

While it is true that the numbers involved are small, it is perhaps significant to note that the fat from the group housed in the heated portion of the barn was slightly firmer according to the mechanical determination.

The second method of arriving at the relative firmness of the fat from the animals in the different groups was a chemical one whereby the "Iodine Number" of each sample of fat was determined. The iodine numbers secured are given in the following table.

Table XXII. Iodine Numbers of Fat Samples.

Lot I		Lot II		Lot III	
Sample No.	Iodine No.	Sample No.	Iodine No.	Sample No.	Iodine No.
1	61.0	6	62.0	11	60.4
2	60.7	7	63.5	12	59.0
3	58.7	8	56.8	13	58.0
4	55.6	9	61.9	14	61.5
5	58.7	10	60.7	15	59.2
Av.	58.9		61.0		59.6

It may be seen that Lot I which yielded carcasses which were slightly firmer according to the mechanical grade, also had the lowest average "Iodine Number".

However subjecting the above data to a brief statistical analysis (Appendix - Table XX) showed that there was not a significant difference between the Groups with respect to the "Iodine Number" of the back fat.

On the basis of the results of this experiment, subjecting pigs to different temperature levels (within a practical range) did not significantly influence the firmness of the fat in the carcass.

EXPERIMENT NO. VI. (SUMMER 1939).

An Experiment to Determine what Influence the Practice of Marketing and Slaughtering Bacon Hogs at Different Weights may have on the Quality of the Carcasses Produced:

In certain quarters, there has been considerable criticism regarding "overfinish" on commercial hogs. If this condition of overfinish does exist in the case of some hogs which are sold and slaughtered, it may well be that it is linked up with the weight at which the pigs are marketed. It would seem quite possible that a bacon hog weighing approximately 200 pounds when slaughtered and carrying the proper amount of finish at that time, would show too much finish if allowed to reach a weight of approximately 225 pounds before being slaughtered. The above mentioned weights

are suggested for two reasons:

1. The minimum and maximum weights respectively for Grade I select bacon hogs fed and watered at stockyards or local shipping-points are 190 and 230 pounds.

2. Bacon hogs weighing approximately 210 pounds are considered the most desirable from the standpoint of weight for the production of good quality Wiltshires.

Objects of the Experiment:

Taking into consideration the foregoing statements, the objects of Experiment No. VI may be stated as follows:-

1. To determine the amount of finish carried by bacon hogs marketed and slaughtered at different weights.

2. To ascertain the influence on carcass quality of marketing bacon hogs at weights of from 195 to 200 pounds as compared with those from 225 to 230 pounds.

Animals Used:

Two groups consisting of six purebred Yorkshire pigs in each were included in this experiment. The two groups were, as in all other experiments, made as similar as possible with respect to initial weight, sex, general type and condition.

Method of Housing:

Both groups of pigs were housed under similar conditions in pens 10' by 12' in the shed piggery at the University Farm.

Arrangement of Groups:

Lot I: Grain Ration, Milk, 1 lb. to 1 lb. of grain, limestone, salt. (Slaughter - 195 to 200 lbs.)

Lot II: Grain Ration, Milk, 1 lb. to 1 lb. of grain, limestone, salt. (Slaughter - 225 to 230 lbs.)

Grain Ration:

The grain ration consisted of the following:

Oats	30	parts	by	weight
Barley	40	"	"	"
Wheat	30	"	"	"

Ground Limestone and Salt:

were added to the grain mixture at the rate of 0.5 lbs. each to 100 lbs. of grain.

Method of Feeding:

Both groups of pigs were hand fed twice daily during the period of the experiment.

Carcass Data:

The animals in Lot I were removed from the experiment at weights ranging from 195 to 200 pounds and those in Lot II were removed at weights ranging from 225 to 230 pounds.

Figures showing the measurements and percentages of the cuts of the carcasses are presented in the following table.

Table XXIII. Measurements and Percentages of the Cuts of Carcasses.

	Lot I	Lot II
Av. Length of Carcass (inches)	29.52	30.85
% Shoulder of Carcass	28.36	27.78
% Ham of Carcass	24.36	24.18
Av. Depth of Shoulder Fat (inches)	1.73	2.00
Av. Depth of Back Fat (inches)	0.97	1.17
Av. Depth of Loin Fat (inches)	1.28	1.63
Av. Min. Belly Thickness (inches)	0.90	0.98
Av. Max. Belly Thickness (inches)	1.70	1.80

It is to be expected that the carcasses from Lot II would show a slightly greater length than those from Lot I, in as much as the animals from the former group were allowed

to reach a somewhat greater degree of maturity before being slaughtered.

It may be noted that there was some difference between the two Lots, with respect to percentage shoulder of carcass. However, such difference was shown not to be significant. (Appendix - Table XXI).

The amount of "finish" as indicated by the fat measurements was significantly greater in the case of Lot II (Appendix - Tables XXII to XXIV). In as much as a fat covering of from 1.25 to 1.50 inches is considered optimum for best carcass quality (45), Lot II showed too much "finish", particularly over the shoulders and to some extent at the loin. The lack of uniformity of depth or thickness of fat as measured over the shoulder, back and loin respectively, is worthy of note. This characteristic does not, however, apply only to the carcasses dealt with in this experiment, but to the majority of those examined in previous experiments as well. It appears to be extremely difficult to obtain an even distribution of fat over the shoulders, back and loin.

Detailed Carcass Measurements:

It may be pointed out here that due to circumstances beyond control, it was not possible to make detailed measurements on all of the rashers secured from the carcasses in this experiment and therefore the results shown are based on a limited number. Only the percentages of lean and fat respectively in the cross-sections were determined and these are shown below:-

Table XXIV. Percentages of Fat and Lean in the Cross-section.

	Lot I	Lot II
Av. Percentage Lean in Cross-section	37.06	31.70
Av. Percentage Fat in Cross-section	62.94	68.30

It will be seen that Lot II consisting of the animals which were not slaughtered until they reached a weight of approximately 230 pounds, showed a somewhat higher percentage of fat and a consequent lower percentage of lean than did Lot I.

Carcass Grade:

It was possible to have an Official of the Dominion Department of Agriculture place a grade upon each individual carcass. All carcasses in Lot I were graded as "leanest lean", (the most desirable), while only three of the carcasses from Lot II received this grade, the others being placed somewhat lower. The main criticism of the carcasses which were not graded as "leanest lean" was that they showed too much fat over the shoulder or over the loin. This bears out the finding presented previously.

While too definite conclusion cannot be drawn, owing to the very limited number of animals used, it would appear from the results of this experiment, that bacon hogs of the type used in this experiment which are full-fed a suitable ration throughout the duration of the feeding period, carry sufficient "finish" when slaughtered at a weight slightly over 200 pounds. Furthermore, if similar hogs are not

slaughtered until they reach approximately 230 pounds in weight, they carry an excess of "finish" and consequently the carcasses contain too much fat in proportion to lean from the standpoint of high carcass quality.

The Effect of Sex on Carcass Quality.

There does not appear to have been any extensive investigation conducted to determine whether or not the sex of the animal has any influence on the quality of carcass produced. However, it was pointed out in the review of literature that Woodman et al (15) and Hammond and Murray (41) found that gilts produced somewhat leaner carcasses than the castrated males. On the other hand, Jari (40) working in Sweden found that gilt carcasses were thicker and had a higher content of fat than those of the barrows.

It seems logical and therefore not altogether hypothetical, that the sex of the animal may have some influence on the quality of carcass produced. In the case of all domesticated animals, the male usually attains a somewhat greater "body development" (size) than the females. Intensified growth probably takes place at somewhat different stages of maturity in the two sexes. This might well lead to a difference in body proportions and measurements which would ultimately be reflected in the carcass.

It is, of course, known that castration of the male animal leads to a change in certain endocrine activities which influence body characteristics. This might result in

a development of body similar to that shown by the female animal.

There appears to be sufficient justification for including the influence of sex, when considering some of the factors which influence carcass quality. While no experiments were outlined to specifically study the sex factor, an attempt has been made to examine and present some of the data from other experiments, on a basis which would yield information on this point.

A Comparison of the Quality of Carcasses Yielded by Males and Females.

Differences Between Pairs of Animals:

The various measurements and proportions were determined on carcasses yielded by seven pairs of animals. Each pair consisted of one male and one female, the male being a full brother to the female in each case. The ration allowed and treatment received by the two members of any one pair were identical.

It may be seen that under the arrangement of pairs, both animals in any one pair were of the same breeding and received identical treatment. Thus any differences in quality of carcass which might exist between the males and females, aside from those due to "individuality", could be attributed to sex influence.

The carcass data on the seven pairs of animals are presented below. Only the averages of various Measurements and Proportions are shown.

Table XXV. Measurements and Proportions of Carcasses Yielded by Animals of Different Sex.

	Males	Females
Av. Length of Carcass (inches)	29.56	30.34
Av. Percentage Shoulder of Carcass	28.42	28.73
Av. Percentage Ham of Carcass	23.89	24.24
Av. Depth of Shoulder Fat (inches)	1.86	1.83
Av. Depth of Back Fat (inches)	1.11	1.03
Av. Depth of Loin Fat (inches)	1.39	1.39
Av. Min. Thickness of Belly (inches)	0.97	0.91
Av. Max. Thickness of Belly (inches)	1.81	1.74
Av. Area of "Eye of Lean" (sq. in.)	3.70	3.80
Av. Percentage "Eye of Lean" of Cross-section	14.11	15.03
Av. Percentage Total Lean in Cross-section	33.55	35.01

A survey of this data reveals that the differences between the males and females were small. It may be noted that the males showed a slightly higher figure for depth of back fat and also showed a somewhat greater "thickness of belly" measurement.

On the other hand the females showed a slightly greater area of "eye of lean" and a greater percentage total lean in cross-section, than the males.

Further data with regard to the influence of sex on the quality of carcasses yielded by swine, were obtained on thirty-three pairs of animals. The male and female included in each pair were not brother and sister, but all of the animals used were of similar breeding. The male and female in any one pair received identical treatment.

The data on the thirty-three pairs of animals are presented in the next table.

Table XXVI. Measurements and Proportions of Carcasses Yielded by Animals of Different Sex.

	Males	Females
Av. Length of Carcass (inches)	30.44	30.37
Av. Percentage Shoulder of Carcass	28.30	28.03
Av. Percentage Ham of Carcass	23.69	24.54
Av. Depth of Shoulder Fat (inches)	1.93	1.86
Av. Depth of Back Fat (inches)	1.13	1.03
Av. Depth of Loin Fat (inches)	1.52	1.41
Av. Min. Belly Thickness (inches)	1.01	0.93
Av. Max. Belly Thickness (inches)	1.83	1.70
Av. Area of "Eye of Lean" (sq. in.)	3.90	4.24
Av. Percentage "Eye of Lean" in Cross-section	14.69	16.93
Av. Total Lean in Cross-section	34.75	37.70

In view of the somewhat larger number of individuals included, it was possible to conduct an "analysis of variance" on some of the carcass data pertaining to the influence of sex. In this manner it was possible to determine whether or not the differences in carcass measurements and proportions between the males and the females, as indicated in the above table, were statistically significant. A summary of the analyses is given in Appendix II.

The results indicate that the males had a significantly greater "depth of back fat," depth of loin fat" and "minimum thickness of belly" respectively, than the females. On the other hand, the females showed a significantly greater "area of eye of lean", "percentage "eye of lean" in cross-section", and "percentage total lean in cross-section" respectively, than the males.

Thus it would appear that the males carried a significantly greater amount of "finish" than the females, and consequently

showed a significantly lower percentage of lean in the cross-section.

These results agree with those obtained by Woodman and others (15) who found that gilts produced somewhat leaner carcasses than the hogs. They also agree in part with the findings of Hammond and Murray (41) who suggested that carcasses produced by sows showed less back fat than those yielded by the castrated male. However, Hammond and Murray further suggest that carcasses produced by females are thicker in the belly than those produced by barrows. The results discussed above do not bear out this statement.

On the basis of the results obtained it would appear that male pigs produce carcasses which carry a significantly greater amount of fat than carcasses yielded by females. It cannot be definitely stated why such should be the case. The explanation suggested by Hammond and Murray (41) is that castration tends to the deposition of fat in the carcass.

GENERAL SUMMARY.

The experiments which have been reported were conducted at the University of Alberta during the period 1936-1940. The chief object in view was to study some of the factors which may influence the quality of carcasses produced by bacon hogs.

A summary of the results of the experiments will now be reported.

Experiment I was initiated to study the effects of varying the level of the protein in the ration on the growth of bacon hogs and on the quality of the carcasses produced by such hogs.

Subjecting the animals to the different levels of protein intake within the range included in this experiment, did not appear to exert any significant influence on the quality of the carcasses yielded. Increasing the amount of protein allowed did not result in any increase in the length of the carcasses, nor did it appear to have any influence on the proportions of shoulder, ham and middle.

The results of this experiment indicated that the amount of protein in the ration did not have any significant influence on the size of the "eye of lean" or the proportion of lean to fat in the carcass. An average daily intake of 0.44 lbs. of Digestible Crude Protein per 100 lbs. liveweight was apparently sufficient to provide for full development of "eye of lean".

Experiment II was outlined to determine the relative merits of skim-milk and a mixed protein supplement respectively in the production of high quality bacon, and to examine the influence of "inside" and "outside" feeding respectively on the growth of bacon hogs and on the quality of the carcasses produced by such hogs.

The carcasses from the "inside fed" pigs showed slightly greater length than those yielded by the pigs which were fed "outside", thus contradicting the popular belief that

"outside feeding" and exercise are conducive to greater length.

The "outside fed" animals showed a somewhat greater percentage shoulder of carcass than those which were fed "inside". However, it was shown that the differences were not significant. From this it would appear that exercise did not result in any significant increase in the size of that portion of the carcass designated as shoulder.

It has been shown that there were no significant differences in the size of the "eye of lean", percentage "eye of lean" in cross-section or percentage total lean in cross-section between the groups which were fed "inside" and those which were fed "outside". This seems to indicate quite clearly that a system of outside feeding where conditions are such that unlimited exercise may be taken by the animal, is not conducive to the production of a leaner carcass.

The average length of the carcasses yielded by the animals which received a mixed protein supplement was slightly greater than that of the carcasses produced by the pigs which received skim-milk. The differences between the groups with respect to percentage shoulder of carcass and percentage ham of carcass, were not significant.

Lot IV, the inside fed group which received the mixed protein supplement, showed a significantly smaller "eye of lean" than Lot III which received skim-milk. However, in view of the fact that the percentage total lean in cross-section for the former group was not significantly less than

the percentage total lean in cross-section for the latter group, it would appear that feeding skim-milk did not significantly influence the amount of lean in the carcass.

The object of experiment III was to note the effect of different planes of nutrition at different stages of maturity on the growth of swine, and to determine the influence of such planes of nutrition on the quality of the carcass.

It has been shown that there were no significant differences in length of carcass between the respective groups of animals. Thus the different planes of nutrition did not exert any significant influence on the length of the carcass.

Lot I, the lot which was "full-fed" throughout the duration of the experiment, showed a significantly less percentage shoulder of carcass.

The amount of "finish" carried by the animals in Lot I was slightly, though not significantly, greater than that shown by the other two groups.

The "limited-fed" groups, particularly Lot III which was limited-fed up to 150 pounds, were deficient in "belly thickness" as indicated both by the measurements and grading.

While there were some differences between the three lots with respect to both size of "eye of lean" and percentage total lean in cross-section, such differences were not statistically significant. Thus it would appear that limiting the amount of feed within the limits outlined in this experiment, either during the early stages or during the latter part of the feeding period, did not have any

significant influence on the proportion of lean to fat in the carcass.

It has been shown that the different methods of feeding as carried out in this experiment did not have any significant influence on the firmness of fat in the carcass.

Experiment IV was conducted with a view to securing further data and information on the influence of methods of feeding on carcass quality, and the outline of the experiment was similar to that of Experiment III.

Due to the small number of animals involved, and the comparatively large differences which existed in the various carcass measurements between carcasses yielded by animals of similar breeding which received identical treatment, little in the way of definite information regarding the influence of the different planes of nutrition on carcass quality could be obtained from those animals which were slaughtered previous to the changes in plane of nutrition being made. The results indicated, however, that the animals which were "limited-fed" produced carcasses which were lacking in "belly thickness". Furthermore, on the basis of the results of this portion of the experiment, limited feeding did not adversely affect the production of lean meat up to the stage at which these pigs were slaughtered.

The results of Experiment IV, on the basis of the six animals in each group which were carried to market weight before being slaughtered, bore out in general, the results obtained in Experiment III.

It has been shown that while the animals which were "full-fed" throughout the duration of the feeding period carried a somewhat greater amount of "finish", there was not a significant difference between the lots with regard to percentage of lean in the carcass, in so far as the percentage of lean in the cross-section can be taken as an index of the percentage lean in the entire carcass.

The results of Experiments III and IV do not agree with the conclusions of McMeekan (28) who states that "restricted growth in early life followed by a rapid fattening to bacon weight produces a carcass in which the lean meat is underdeveloped and the covering of fat excessive". The pigs which were "limited-fed" during the first part of the feeding period in the above-mentioned experiments, certainly did not carry an excessive amount of fat, and the carcasses were found to lack sufficient "thickness of belly".

Experiment V was conducted to determine the influence of temperature on the growth of swine and on the general quality of the carcasses yielded, with particular reference to the firmness of the fat.

The results of this experiment indicated that there were no significant differences in the general carcass measurements and proportions between the respective groups of animals included in the experiment.

The firmness of the fat in the carcasses was determined both by mechanical and chemical means. The results indicated that subjecting pigs to different temperature levels

(within the range described in this experiment) did not significantly influence the firmness of the fat in the carcasses.

Experiment VI was outlined to determine the amount of "finish" carried by bacon hogs slaughtered at different weights, and to ascertain the influence on carcass quality of marketing bacon hogs at weights ranging from 195 to 200 pounds as compared with those ranging in weight from 225 to 230 pounds.

The results of this experiment indicated that there were no significant differences with respect to percentage ham of carcass or percentage shoulder of carcass, between the carcasses yielded by the heavier pigs in Lot II and those yielded by the lighter animals in Lot I. The animals in Lot II showed too much "finish", particularly over the shoulders and to some extent at the loin. This was borne out in the detailed measurements of the cross-sections, the results of which indicated a higher percentage of fat in the carcasses yielded by Lot II. A greater number of the carcasses yielded by the Lot I animals, which were slaughtered at the lower weight range, received the highest Official Carcass Grade than those yielded by the animals which were slaughtered at the higher weights.

Some data have been presented to show what influence the sex of the animal may have on the quality of the carcass produced. It has been shown that the males carried a significantly greater amount of "finish" as indicated by depth

of loin fat, depth of back fat, and thickness of belly, whereas the females showed a significantly greater area of "eye of lean" and a significantly greater percentage total lean in cross-section.

CONCLUSIONS.

The following conclusions may be drawn from the results of the experiments and analyses which have been reviewed in this manuscript:-

1. Increasing the amount of protein supplement in the ration led to slightly higher gains in liveweight, but the optimum intake of Digestible Crude Protein appeared to be 0.55 lbs. daily per 100 lbs. of liveweight.

2. Varying the amount of protein in the ration whereby the Digestible Crude Protein intake was varied from 0.44 lbs. to 0.56 lbs. daily per 100 lbs. of liveweight, did not significantly influence the quality of the carcasses yielded by the animals.

3. Mixed protein supplements make a satisfactory substitute for skim-milk as a feed for swine, and therefore lack of skim-milk is not a limiting factor in the production of high quality bacon.

4. Exercise does not appear to influence the proportions or measurements of the carcasses yielded by bacon hogs.

5. High quality carcasses may be produced by bacon hogs which are raised under a system of "inside" feeding.

6. Limiting the amount of feed which bacon pigs receive to two-thirds full-feed, from weaning time until the pigs weigh 140 pounds and then full-feeding until they reach market weight, or full-feeding for the first period and then limiting the amount of feed to two-thirds for the remainder of the feeding period, does not appear to significantly influence the proportion of, or the percentage of lean in the carcasses yielded.

7. Pigs which are "limited-fed" from weaning time to 140 pounds, and then "full-fed" to market weight, produce carcasses which are lacking in "thickness of belly".

8. The external temperature, within practical limits, to which pigs are subjected, does not significantly influence the firmness of fat in the carcasses yielded.

9. Bacon pigs of the type used in these experiments, which are "full-fed" throughout the entire feeding period, carry sufficient "finish" when weighing approximately 210 pounds.

10. Similar animals which are "full-fed" for the entire feeding period, and which are not slaughtered until they weigh approximately 230 pounds, carry an undesirable amount of "finish" from the standpoint of quality of carcass.

11. There are indications that the sex of the animal has some influence on the quality of the carcass produced. Carcasses produced by barrows carry a significantly greater amount of "finish" as indicated by depth of fat over the loin, depth of back fat, and thickness of belly, than those

yielded by gilts. On the other hand, carcasses yielded by gilts show a significantly greater area of "eye of lean" and a significantly greater percentage total lean in cross-section, than those produced by barrows.

12. There are wide variations, with regard to carcass measurements as referred to in the experiments reviewed, between individuals of similar breeding which received identical treatment, and this leads to extreme difficulty in the interpretation of the results of such experiments. It would appear that in conducting similar investigations, there is need for the use of greater numbers of animals.

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APPENDIX I

Some of the data presented in this manuscript has been subjected to a brief statistical analysis. The main purpose of this was to determine whether or not the differences obtained for such factors as length, proportion, size of "eye of lean" etc. between groups of animals subjected to different treatments were significant.

The method used is that presented by Goulden (46). The T value for a given set of data was determined in each instance. The necessary T value to be significant at the 0.05 point was found by reference to tables presented by Goulden (46).

Table I. Length of Carcasses

Experiment #I:

	Lot I	Lot II	Lot III	Lot IV
	31.6 inches	30.5 inches	30.2 inches	32.3 inches
	30.8 "	30.5 "	30.2 "	30.7 "
	31.2 "	30.3 "	30.2 "	30.5 "
	29.6 "	31.8 "	30.5 "	30.0 "
	30.3 "	31.4 "	30.3 "	30.9 "
Av.	30.7 "	30.9 "	30.3 "	30.5 "

T value for Lots II and III = 1.98

Necessary T value to be significant at the 0.05 point = 2.31

Table II. Percentage Shoulder of Carcass

Experiment #I:

	Lot I	Lot II	Lot III	Lot IV
	26.62 inches	27.34 inches	27.39 inches	28.97 inches
	27.08 "	29.00 "	27.68 "	26.69 "
	28.06 "	25.85 "	28.46 "	27.84 "
	28.73 "	28.37 "	27.80 "	27.70 "
	28.78 "	27.91 "	28.79 "	27.34 "
Av.	27.85 "	27.69 "	28.02 "	27.71 "

T value for Lots II and III = 0.55

Necessary T value to be significant at the 0.05 point = 2.31

Table III. Percentage Ham of Carcass

Experiment #I:

	Lot I	Lot II	Lot III	Lot IV
	22.30 inches	23.02 inches	23.02 inches	22.97 inches
	22.74 "	24.16 "	22.14 "	23.84 "
	23.74 "	23.46 "	24.62 "	23.44 "
	25.00 "	23.40 "	24.19 "	24.10 "
	23.98 "	23.64 "	23.48 "	24.10 "
Av.	23.55 "	23.54 "	23.49 "	23.69 "

T value for Lots III and IV = 0.41

Necessary T value to be significant at the 0.05 point = 2.31

Table IV. Percentage Total Lean in Cross Section

Experiment #I:

	Lot I	Lot II	Lot III
	23.78 inches	27.56 inches	32.00 inches
	32.17 "	33.55 "	25.87 "
	33.86 "	29.77 "	32.07 "
	31.99 "	33.14 "	33.88 "
			27.55 "
Av.	30.45 "	31.00 "	30.29 "

T value for Lots II and III = 0.35

Necessary T value to be significant at the 0.05 point = 2.36

Table V. Percentage Shoulder of Carcass

Experiment #II:

	Lot I	Lot II	Lot III	Lot IV
	30.57 inches	29.76 inches	28.08 inches	27.96 inches
	29.40 "	28.75 "	28.76 "	28.24 "
	28.79 "	28.15 "	27.27 "	27.39 "
	26.82 "	27.77 "	27.77 "	28.40 "
	28.62 "	29.77 "	28.44 "	28.57 "
	27.51 "	27.27 "	26.27 "	26.75 "
Av.	28.62 "	28.58 "	27.76 "	27.88 "

T value for Lots I and III = 1.31

Necessary T value to be significant at the 0.05 point = 2.23

T value for Lots II and IV = 1.37

Necessary T value to be significant at the 0.05 point = 2.23

T value for Lot I + Lot II and Lot III + Lot IV = 1.87

Necessary T value to be significant at the 0.05 point = 2.09

Table VI. Percentage Ham of Carcass

Experiment #II:

	Lot I	Lot II	Lot III	Lot IV
	24.46 inches	24.21 inches	25.05 inches	23.26 inches
	23.79 "	25.05 "	25.10 "	24.05 "
	24.05 "	24.08 "	25.23 "	23.16 "
	23.95 "	24.27 "	22.67 "	25.52 "
	23.73 "	24.44 "	24.29 "	23.62 "
	23.76 "	24.44 "	23.19 "	23.91 "
Av.	23.96 "	24.42 "	24.26 "	23.92 "

T value for Lots II and IV = 1.34

Necessary T value to be significant at the 0.05 point = 2.23

Table VII. Area of "Eyes of Lean"

Experiment #II:

	Lot I	Lot II	Lot III	Lot IV
	3.97 sq. in.	5.21 sq. in.	3.92 sq. in.	3.62 sq. in.
	3.76 " "	3.91 " "	4.26 " "	3.81 " "
	4.06 " "	3.85 " "	4.33 " "	3.95 " "
	4.04 " "	3.68 " "	4.15 " "	4.18 " "
	4.85 " "	4.85 " "	4.92 " "	3.97 " "
	4.86 " "	4.01 " "	4.33 " "	
Av.	4.26 " "	4.25 " "	4.32 " "	3.91 " "

T value for Lots III and IV = 2.39

Necessary T value to be significant at the 0.05 point = 2.26

T value for Lots II and IV = 1.94

Necessary T value to be significant at the 0.05 point = 2.26

Table VIII. Percentage "Eye of Lean" in Cross-sections

Experiment #II

	Lot I	Lot II	Lot III	Lot IV
	15.08	21.04	15.18	14.04
	14.80	16.29	15.87	13.28
	15.00	14.82	16.72	16.70
	14.25	14.28	12.85	15.14
	17.20	20.12	18.83	14.92
	17.08	16.74	18.53	———
Av.	15.57	17.22	16.33	14.82

T value for Lots II and IV = 1.77

Necessary T value to be significant at the 0.05 point = 2.26

Table IX. Percentage Total Lean in Cross-section

Experiment #II:

	Lot I	Lot II	Lot III	Lot IV
	37.61	41.12	33.84	30.92
	31.58	36.81	41.78	28.66
	38.19	35.62	35.82	35.64
	34.71	34.33	31.10	32.97
	39.10	46.20	44.28	35.17
	39.55	37.50	38.81	———
Av.	36.79	38.60	37.60	32.67

T value for Lots III and IV = 1.95

Necessary T value to be significant at the 0.05 point = 2.26

T value for Lots II and IV = 2.62

Necessary T value to be significant at the 0.05 point = 2.26

T value for Lot I + Lot II, and Lot III + Lot IV = 1.62

Necessary T value to be significant at the 0.05 point = 2.08

Table X. Length of Carcasses

Experiment #III:

	Lot I	Lot II	Lot III
	30.5 inches	30.4 inches	30.2 inches
	30.0 "	32.2 "	30.5 "
	30.5 "	29.8 "	30.8 "
	30.0 "	30.5 "	31.0 "
	31.8 "	30.5 "	29.9 "
	32.0 "	31.0 "	30.8 "
Av.	30.8 "	30.7 "	30.5 "

T value for Lots I and III = 0.68

Necessary T value to be significant at the 0.05 point = 2.23

Table XI. Percentage Shoulder of Carcass

Experiment #III:

	Lot I	Lot II	Lot III
	26.24	27.92	28.92
	28.78	28.63	29.02
	28.47	30.22	29.59
	28.79	29.37	28.57
	27.56	28.36	29.80
	25.55	31.20	29.89
Av.	27.56	29.28	29.30

T value for Lots I and III = 2.89

Necessary T value to be significant at the 0.05 point = 2.23

T value for Lots I and II = 2.27

Necessary T value to be significant at the 0.05 point = 2.23

Table XII. Depth of Loin Fat

Experiment #III:

	Lot I	Lot II	Lot III
	1.4 inches	1.4 inches	1.2 inches
	1.3 "	1.5 "	1.4 "
	1.8 "	1.3 "	1.3 "
	1.5 "	1.4 "	1.2 "
	1.5 "	1.2 "	1.5 "
	1.6 "	1.1 "	1.0 "
Av.	1.5 "	1.3 "	1.3 "

T value for Lots I and III = 2.0

Necessary T value to be significant at the 0.05 point = 2.23

Table XIII. Area of Eye of Lean

Experiment #III:

	Lot I	Lot II	Lot III
	3.84 sq. in.	4.40 sq. in.	4.28 sq. in.
	4.64 " "	4.52 " "	5.21 " "
	3.99 " "	4.35 " "	4.82 " "
	4.27 " "	3.94 " "	4.87 " "
	4.39 " "	4.35 " "	4.21 " "
	3.91 " "	3.84 " "	4.24 " "
Av.	4.17 " "	4.23 " "	4.60 " "

T value for Lots I and III = 1.99

Necessary T value to be significant at the 0.05 point = 2.23

Table XIV. Percentage Total Lean in Cross-section

Experiment #III:

	Lot I	Lot II	Lot III
	36.07	42.93	47.65
	44.77	40.81	40.47
	36.60	42.35	44.07
	41.23	36.65	42.53
	36.78	40.92	39.78
	41.24	39.53	41.70
Av.	39.45	40.53	42.70

T value for Lots I and III = 1.76

Necessary T value to be significant at the 0.05 point = 2.23

Table XV. Length of Carcasses

Experiment #IV:

	Lot I	Lot II	Lot III
	29.8 inches	29.0 inches	29.4 inches
	29.3 "	29.9 "	29.1 "
	31.0 "	31.2 "	29.3 "
	29.6 "	29.6 "	30.5 "
	30.3 "	30.6 "	31.8 "
	31.2 "	29.8 "	29.9 "
Av.	30.2 "	30.0 "	30.0 "

T value for Lots I and III = 0.41

Necessary T value to be significant at the 0.05 point = 2.23

Table XVI. Percentage Shoulder of Carcass

Experiment IV:

	Lot I	Lot II	Lot III
	30.87	25.42	28.86
	27.22	29.03	28.73
	28.35	28.78	28.49
	28.21	25.59	28.32
	26.13	27.90	28.84
	28.22	27.83	27.90
Av.	28.17	27.42	28.52

T value for Lots II and III = 1.68

Necessary T value to be significant at the 0.05 point = 2.23

Table XVII. Area of Eye of Lean

Experiment IV:

	Lot I	Lot II	Lot III
	6.30 sq. in.	6.08 sq. in.	5.28 sq. in.
	4.76 " "	4.96 " "	6.08 " "
	5.76 " "	7.48 " "	7.14 " "
	5.76 " "	5.94 " "	6.27 " "
	5.19 " "	5.78 " "	6.65 " "
	6.27 " "	5.70 " "	6.08 " "
Av.	5.67 " "	5.99 " "	6.25 " "

T value for Lots I and III = 1.23

Necessary T value to be significant at the 0.05 point = 2.23

Table XVIII. Area of Eye of Lean in Square Inches

Experiment #V:

	Lot I	Lot II	Lot III
	4.43	4.07	4.15
	4.76	5.32	4.50
	3.15	3.97	3.38
	4.03	4.04	5.56
	3.41	4.65	3.94
Av.	3.96	4.41	4.31

T value for Lots I and II = 1.14

Necessary T value to be significant at the 0.05 point = 2.31

Table XIX. Percentage Total Lean

Experiment #V:

	Lot I	Lot II	Lot III
	37.54	37.01	37.68
	38.44	41.64	39.06
	33.63	37.12	31.11
	34.05	46.11	44.14
	33.97	40.91	44.04
Av.	35.53	40.56	39.21

T value for Lots I and II = 2.56

Necessary T value to be significant at the 0.05 point = 2.31

T value for Lots I and III = 1.41

Necessary T value for significance at the 0.05 point = 2.31

Table 4.107. [illegible]

[illegible]:

[illegible]	[illegible]	[illegible]
0.49	4.34	0.0
1.74	3.84	0.0
3.24	4.39	0.0
4.05	4.84	0.0
5.03	5.00	0.0
6.00	5.00	0.0
7.31	5.14	0.0

[illegible]

[illegible]

Table 4.108. [illegible]

[illegible]:

[illegible]	[illegible]	[illegible]
47.34	34.0	0.0
50.46	34.01	0.0
50.03	34.18	0.0
54.38	34.0	0.0
56.42	34.01	0.0
58.42	34.34	0.0

[illegible]

[illegible]

[illegible]

Table XX. Iodine Number

Experiment #V:

	Lot I	Lot II	Lot III
	61.0	62.0	60.4
	60.7	63.5	59.0
	58.7	56.8	58.0
	55.6	61.9	61.5
	58.7	60.7	59.2
Av.	58.9	61.0	59.6

T value for Lots I and II = 1.37

Necessary T value to be significant at 0.05 point = 2.31

Table XXI. Percent Shoulder of Carcass

Experiment #VI:

	Lot I	Lot II
	29.03	26.43
	28.63	28.02
	28.87	27.80
	27.38	27.87
	28.15	29.19
	28.10	27.40
Av.	28.36	27.78

T value = 1.30

Necessary T value to be significant at the 0.05 point = 2.23

Table XXII. Depth of Shoulder Fat

Experiment #VI:

	Lot I	Lot II
	1.9 inches	2.3 inches
	1.8 "	2.1 "
	1.5 "	1.8 "
	1.8 "	1.7 "
	1.9 "	2.2 "
	1.5 "	1.9 "
Av.	1.7 "	2.0 "

T value = 2.33

Necessary T value to be significant at the 0.05 point = 2.23

Table XXIII. Depth of Back Fat

Experiment #VI:

	Lot I	Lot II
	0.9 inches	1.4 inches
	0.9 "	1.0 "
	1.0 "	1.1 "
	1.0 "	1.0 "
	1.1 "	1.2 "
	0.9 "	1.3 "
Av.	1.0 "	1.2 "

T value = 2.45

Necessary T value to be significant at the 0.05 point = 2.23

Table XXIV. Depth of Loin Fat

Experiment #VI:

	Lot I	Lot II
	1.1 inches	1.7 inches
	1.4 "	1.6 "
	1.3 "	1.5 "
	1.3 "	1.4 "
	1.4 "	1.8 "
	1.2 "	1.8 "
Av.	1.3 "	1.6 "

T value = 3.67

Necessary T value to be significant at the 0.05 point = 2.23

Necessary T value to be significant at the 0.01 point = 3.17

APPENDIX II

An analysis of Variance was conducted on some of the carcass data pertaining to the influence of sex. A summary of the analysis is presented in the tables shown below. The necessary F-values to be significant, according to Goulden (46) are: 5% point = 4.15; 1% point = 7.50.

Table I. Depth of Back Fat

Source of Variance	D.F.	S.S.	M.S.	F.
Between pairs	32	0.838	0.026	
Within pairs	1	0.175	0.175	*5.68
Error	32	0.985	0.0308	
Total	65	1.998		

Table II. Depth of Loin Fat

Source of Variance	D.F.	S.S.	M.S.	F.
Between pairs	32	1.54	0.048	
Within pairs	1	0.22	0.22	*5.5
Error	32	1.39	0.04	
Total	65	3.15		

Table III. Minimum Belly Thickness

Source of Variance	D.F.	S.S.	M.S.	F.
Between pairs	32	0.85	0.027	
Within pairs	1	0.09	0.09	**8.74
Error	32	0.33	0.0103	
Total	65	1.27		

Table IV. Percentage Ham of Carcass

Source of Variance	D.F.	S.S.	M.S.	F.
Between pairs	32	47.004	1.469	
Within pairs	1	11.981	11.981	**11.67
Error	32	32.855	1.027	
Total	65	91.840		

Table V. Area of Eye of Lean

Source of Variance	D.F.	S.S.	M.S.	F.
Between pairs	32	10.359	0.324	
Within pairs	1	1.935	1.935	*5.86
Error	65	10.552	0.330	
Total	65	22.846		

Table VI. Percentage Total Lean in Cross-section

Source of Variance	D.F.	S.S.	M.S.	F.
Between pairs	32	990.397	30.950	
Within pairs	1	217.336	217.336	**15.64
Error	32	444.813	13.900	
Total	65	1652.546		

* Significant at the 5% point.

** Significant at the 1% point.

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